Written By Miltiadis A. Boboulos, Ph.D.



Fire suppression in the Wildland Urban Interface: A wildland fire technology handbook

TABLE OF CONTENTS

CHAPTER 1: FIRE BASICS

1.1 Definition of fire

Fire is a process of intensive oxidation accompanied by a release of a large quantity of heat and also in most cases by the emission of light. It is an exothermic reaction - releasing heat, as opposed to an endothermic reaction that takes in heat (like a chemical cold pack). Some authors (Holleman – Wiberg, 1961) provide a fairly short definition: "Fire is a rapid oxidation reaction releasing smoke, heat, and light". Fire is externally displayed by the release of a large quantity of heat, glow or flame.

When considered related to the subject of the present project, Erickson (1990) reports that when forest fuels burn, there is a chemical combination of the oxygen in the air with woody material, pitch and other burnable elements found in the forest environment. This process is known as *Combustion*. Combustion is a chain reaction chemically similar to photosynthesis in reverse.

Photosynthesis requires a large amount of heat, which is furnished by the sun. The Combustion process releases this heat. The combustion process or "fire" is sometimes called "*rapid oxidation*." It is similar to the formation of rust on iron or the decay of dead wood in the forest, except that the process is drastically speeded up (Erickson, 1990).

1.2 Basic prerequisites for the fire occurrence

Fire begins with ignition. The match is a common ignition device. Friction creates sufficient heat to ignite the phosphorus on the end of the match. Combustion occurs and the match flames.

The combustion process involves a chemical transformation between a substance or substances called fuels and other chemical called oxidisers. Combustion is the rapid oxidation (combination with oxygen) of a fuel resulting in the release of usable heat and production of a visible flame. In addition to fuel and oxidiser, often an ignition source is needed. For example, one of the earliest forms of combustion, the forest fire, uses wood as fuel, the air as the oxidiser and the ignition source can be a spark (lightning) (Erickson, 1990).

Heat is necessary to begin the combustion process. Once started, fire produces its own heat. Wild land fires originate from such sources of heat as matches, embers from cigarettes, cigars or pipes, campfires, trash fires, exhaust sparks from railroad locomotives, sparks from brake shoes or "hot-box" on railroad cars, lightning, spontaneous combustion, hot ashes and arson.

Three things are required in proper combination before ignition and combustion can take place - ***Heat, Oxygen (Oxidiser)*** and ***Fuel***.

A good starting reference for combustion chemistry is Kuo, K. K. (1986) Principles of Combustion, John Wiley and Sons, New York. Probably, the most important issues related to combustion/fire chemistry for a fire scientist are summarized in the fire triangle visualised in figure 1.

Thus it is obvious that these three elements must be present and satisfactorily combined before combustion can occur and continue. For the sake of simplicity we call this the "*Fire Triangle*."

Remove any one of the three sides or elements and the fire will cease to burn. Weaken any one, and the fire will weaken. Increase any one or more of the elements, and the fire will increase in intensity. Armed with this knowledge the fire fighter or the prescribed burner can do much to manage a fire.

Sources of heat are the Sun, Atomic, Volcanoes and Fires. With a continuous supply of heat (furnished by the combustion process itself), the ignition of additional fuel will continue as long as there is enough oxygen present.

Oxidisers

The oxidiser is a substance that will oxidise a fuel. The oxygen is the most typical oxidiser agent employed in combustion.

The oxygen supply for combustion usually comes from the air, because the pure oxygen abstention is expensive and difficult. Because air contains a large proportion of nitrogen, the required volume of air is much grater than the required volume of pure oxygen.

The nitrogen in the air does not take part in the combustion reaction (it just goes along for the ride). It does, however, absorb some of the heat with the result that the heat energy is spread thinly throughout a large quantity of nitrogen and the combustion products. This means that a much lower flame temperature results from air instead of pure oxygen.

Fuel

A fuel is defined as any substance, solid, liquid or gaseous which may be easily ignited and burned to produce heat, ligth or other useful forms of energy. As some examples, we have the following: coal and charcoal, gasoline, kerosene, ligth oils, fuel oils, natural gas, liquified petroleum gases, hydrogene, etc. Most often the fuel considered for out particular subject is organic matter. Most fuels contain carbon, hydrogen, and sometimes sulphur. As a simplification, we might say that combustion consist of the following three processes:

```
carbon + oxygen --------> carbon dioxide + heat
hydrogen + oxygen -------> water vapour + heat
sulphur + oxygen -------->sulphur dioxide + heat
```

The three final compounds listed above are called combustion products. The most important aspect of these reactions is that all release a heat amount.

1.3 Fire flame layers

According to Kuo (1986) basic fire flame layers are as follows:

- Fuel heat-uparea;
- Initial reaction zone – this is where the oxidation of the fuel takes place and the result is CO (carbon monoxide);
- Secondary reaction zone – CO is oxidised to CO_2;
- Recombining (cooling) zone for the resultant combustion products.

The flame is a result of heating up and light emissions and also of unburned heated-up particles. Light emissions come mainly from the second zone (initial reaction zone). Fuels burn without flames when the volatile substance content in them is low.

Fire front

The fire front is the boundary between the products of combustion and the cool still unheated fuel system. The fire front can be either of a laminar or turbulent type (strong turbulence). This depends on the speed of spreading of the fire front. The following factors influence the speed of spreading:

- The fuel-oxidiser ration;
- Initial temperature and pressure;
- The presence of inert substances (components). Such non-combustible elements are normally called fire retardants.

Classes of fire:

- A (in a triangle) - ordinary combustibles: wood and paper
- B (in a square) flammable liquids
- C (in a circle) A or B fires with electricity involved
- D (in a star) Combustible Metals

There can also be combinations of some of the classes mentioned above. Fire class A is the one which will be considered for the purposes of the current project.

1.4 Mechanism of initiating the fire process

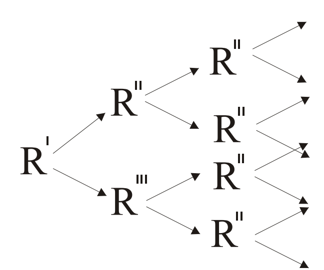
According to Gutmenn (1995) fire is initiated in several different ways:

1. *Heating mechanism:* the process of oxidation of fuel substances in a given system develops into a fire process when sufficiently large quantity of heat energy is present in the system.

2. *Auto-catalytic mechanisms:* some of the products of oxidation have the role of catalysis. As a result of the build-up of this particular product in a particular moment the speed of oxidation is suddenly increased and this starts a fire process.

3. *Radical chain mechanism:* The following two stages are involved here:

- *Loading the oxidation chain – the time in which radicals (active particles) appear somehow within the system;*
- *Stages of extending the chain – each active particle from the processes taking place within the system starts a new R' → R'';*
- *Chain branching:*



- *Chain interruptions – active particles give up their energy.*

A fire process is initiated when the speed of chain branching becomes higher than the speed of chain interruptions.

1.5 Heat Transfer

How much heat is required to ignite forest fuels? Vegetative material such as forest fuels ignites at relatively low temperatures provided the amount of moisture in the fuel is low and it is exposed to the air so that sufficient oxygen is available. Actual heat requirements for ignition of dead forest fuels varies from about 500° to 750° F. Many common ignition sources will provide enough heat including a burning match and even a glowing cigarette when in contact with fine fuels that are dry.

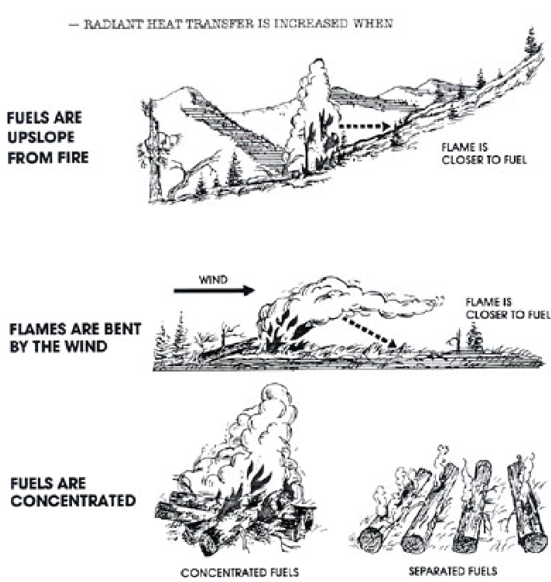
Ignition temperature for dry forest fuels = 500º - 750º F.

We know of many methods where heat can be applied to forest fuels to start the combustion process; but how is the process continued? A fire spreads by transferring heat energy in four ways: *Radiation, Convection, Conduction* and *Direct flame contact (Eriksson, 1990).*

Radiation

Radiation refers to the emission of energy in rays or waves. Heat moves through space as energy waves. It is the type of heat one feels when sitting in front of a fireplace or around a campfire. It travels in straight lines at the speed of light. This is the reason that when facing the fire, only the front is warmed. The backside is not warmed until the person turns around.

The earth is heated by the sun through radiation. Sunburns are a "fact of life" when people are exposed to the sun very long. Most of the preheating of fuels ahead of a fire is by radiation of heat from



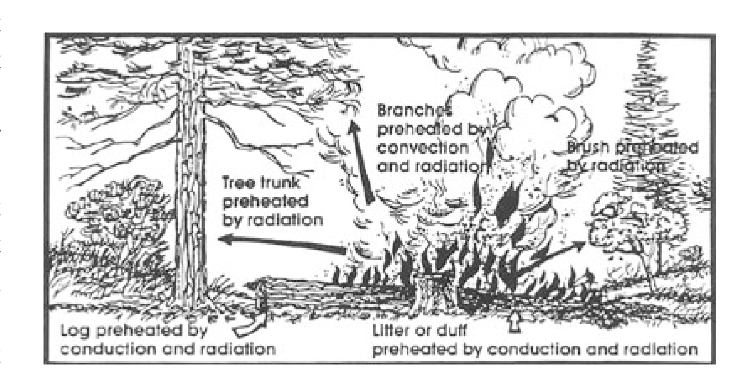
the fire. As the fire front gets closer, the amount of radiant heat received is increased.

Convection

Convection is the transfer of heat by the physical movement of hot masses of air. As air is heated, it expands (as do all objects). As it expands, it becomes lighter then the surrounding air and it rises. (This is why the air near the ceiling of a heated room is warmer than that near the floor.) The cooler air rushes in from the sides. It is heated in turn and it also rises. Soon a convection column is formed above the fire which can be seen by the smoke that is carried aloft in it. This “in-draft” of cooler air from the side helps to supply additional oxygen for the combustion process to continue.

Conduction

Conduction is the transfer of heat within the material itself. Most metals are good heat conductors. Wood is a very poor conductor so it transmits heat very slowly. This can be illustrated by the fact that a wooden handle on a hot frying pan remains cool enough to be held by the bare hands. Conduction is not an important factor in the spread of forest fires.



1.6 Fuel systems

Depending on the physical condition of the combustible substance fuel systems can be either homogeneous or heterogeneous (Riedel, 1990).

The combustible substance in homogeneous fuel systems is in gaseous physical condition or in the form of vapour/air mixtures (O_2). From a speed of combustion viewpoint, homogeneous systems could also include fuel systems containing a combustible substance in a spray system (fine drops), although this is a different physical condition. Combustion taking place in a homogeneous system is referred as normal fire process.

Fuel substances in heterogeneous systems are either in liquid or solid form and air plays the role of the oxidiser. We should point out here, that since our particular project deals with studies on forest fires, our interest will be mainly on heterogeneous systems of fire where the bio mass made up of wood, grass, leafs, soil, etc. has the role of a fuel.

CHAPTER 2: CONVENTIONAL SUPPRESSION EQUIPMENT

2.1. Ground fire equipment

2.1.1 Trucks

A fire truck is one of the most versatile pieces of fire apparatus in use on a wildland fire. It carries personnel and equipment - hoses, water, class A foam, handtools - to a wildland incident. These tools and equipment allow fire crews to attack fires by direct or indirect attack methods.

Wildland engine companies also do mop-up operations and patrol firelines. On a wildland interface fire, wildland engines are used to provide structure protection and to apply Class A foam or fire-blocking gel to structures.

A wildland truck usually has **high ground clearance** and a **short wheelbase**. The truck should have the ability to mobile pump. In order for the engine to be able to mobile pump, it must have a separate pump engine or a power takeoff unit.

AD-FAB is a custom fire apparatus manufacturer, specializing in urban interface and wild land equipment solutions.

AD-FAB: Darley
KSP 750 Pump with Primer
300 gallon Stainless Steel Tank
AuraGen engine driven Generator
Havis Sheild Magnafire 3000
Telescoping Lights
Rear Slide Out Drawers
12,000 Winch
Fire Extinguisher holders in wheel wells
Adjustable shelving



AD-FAB: Lefthand Brush Truck
300 gallon tank
15 gallon foam tank
Steel tubing bed frame
Wildland tool storage in lower compartment
Hydro Wicks BN4200
Robwen foam System





AD-FAB: F-550 4 x 4
400 gallon Stainless Steel LOW PROFILE water tank
Darley 1-1/2 AGE LD High Pressure
Front Spray Bars
FoamPro 1601
10 gallon integrated foam tank
Lower Stainless Steel Compartments



CAMIVA 190 E 30 4x4



Bodywork - Monobloc 2 Lockers built-in the tank
Water capacity 6000 L
CAMIVA pump - Flow upto 1500 L/Mn
Foam compound - Capacity adapted to the Water capacity
MONITOR - Manually controlled,
Flow upto 1200 L/Mn - Manually or Electrically,
Miscellaneous - Front winch

CAMIVA 190 E 30 4x4



Bodywork - 2 Large Lockers
Water capacity: From 10000 L to 13000 L
CAMIVA pump - Flow upto 2000 L/Mn High pressure 250 L/Mn/40 Bars
Foam compound - Capacity adapted to the Water capacity
Powder - YES
MONITOR - Manually controlled
Flow upto 1,200 L/Mn - Electrically controlled,

CAMIVA 1824 4X4



Bodywork - Monobloc
Water capacity 8000 L
CAMIVA pump - Flow upto 1000 L/Mn High pressure 250 L/Mn/40 Bars
Foam compound - Capacity adapted to the Water capacity
MONITOR - Manually controlled,
Flow upto 900 L/Mn - Electrically controlled,

CAMIVA M210 10 4X4



Bodywork - Monobloc 4 Lockers built-in the tank
Water capacity from 2000 L to 2500 L or 4500 L
CAMIVA pump - Flow upto 1000 L/Mn High pressure 250 L/Mn/40 Bars
Motorpump 750L/Mn 10 Bars
Foam compound - Capacity adapted to the Water capacity
MONITOR - Manually controlled,
Flow upto 900 L/Mn
Miscellaneous - Front winch

CAMIVA - RENAULT V.I. chassis type M210 12 4X4
Bodywork - Monobloc 2 Lockers built-in the tank
Water capacity - 3from 500 L to 4000 L
CAMIVA pump - Flow upto 1000 L/Mn High pressure 250 L/Mn/40 Bars
Motorpump 750L/Mn 10 Bars
Foam compound - Capacity adapted to the Water capacity
MONITOR - Manually controlled,
Flow upto 900 L/Mn - Electrically controlled,
Miscellaneous - Front winch, Cab protection , Vehicle auto protection





CAMIVA - RENAULT V.I. chassis
type : KERAX 300.19 4x2.
Bodywork - 2 Large Lockers
Water Capacity - from 6000 L to 10000 L
CAMIVA pump - Flow upto 2000 L/Mn High pressure 250 L/Mn/40 Bars
Foam compound - Capacity adapted to the Water capacity
Powder - YES
MONITOR - Manually controlled
Flow upto 1,200 L/Mn - Electrically controlled.



CAMIVA - RENAULT V.I. chassis
type : CLR 230.19 4X4
Bodywork - 4 Lockers built-in the tank
CAPACITE EAU - From 7000 L to 10000 L
CAMIVA pump - Flow upto 4000 L/Mn High pressure 250 L/Mn/40 Bars
Foam compound - Capacity adapted to the Water capacity
Powder - YES
MONITOR - Manual control
Flow upto 2400 L/Mn Electrically controlled



E-ONE
Model ***Jack Rabbit*** is a 4x4 wildland pumper with larger and deeper compartments and a wide array of options. It fully complies with the latest edition of NFPA 1906.

It features:

- Ford F450 or F550 models
- 30º side-slope capability verified by actual tilt-table tests and high angles of approach and departure for superior off-road capability
- Enclosed suction hose storage and a hideaway rear step

Popular options include:

- Foam systems including CAFS
- Brush bumpers and winches



E-ONE

The ***Super Lynx PR™*** is a 4x4 compact wildland/urban interface pumper with a larger capacity pump to handle multiple hose lines. It fully complies with the latest edition of both NFPA 1901 and NFPA 1906.

It features:

- Ford F-550 or Freightliner and International "Lo Pro" chassis models
- Extruded Aluminum body for high strength, light weight and corrosion resistance
- 30º side-slope capability verified by actual tilt-table tests and high angles of approach and departure for superior off-road capability



Popular options include:

- Foam systems
- Generator and telescoping area lights or light towers

E-ONE

The ***Puma™*** is a wildland/urban interface pumper with additional pump, tank, and equipment capacity to handle structure fires. It fully complies with the latest editions of both NFPA 1901 and NFPA 1906.

It features:

- High-side rescue style compartments with enclosed pump panels
- Short wheelbase with high angles of approach and departure to negotiate narrow roads and steep driveways
- Rear hose bed and two (2) 1-1/2" crosslays

Popular options include:

- 4x2 and 4x4 drive
- Foam systems including CAFS
- Generators and light towers
- Brush bumpers and winches



E-ONE

The ***Typhoon™*** pumper specifications include:

- Hale and Waterous pumps rated from 750 to 2,000 gpm
- Polypropylene water tanks up to 1,800 gallons
- Cummins and Detroit Diesel engines rated from 330 to 400 bhp
- Seating for up to eight (8) persons



E-ONE

The ***Titan® HPR G-Series*** is a high performance vehicle designed for customers who must meet FAA, NFPA, and ICAO standards. It comes with a 3,210 gallon (12,150 liter) water tank and offers outstanding performance

It features:

- GRP components have excellent corrosion resistance to saltwater, galvanic reaction, and many chemicals.
- 80° up and 30° down visibility with a panoramic view to the sides for a commanding view from the cab.
- Independent suspension system with variable rate coil springs on all axles for superior handling and stability during high-speed turning maneuvers and while traversing rough terrain

Popular options include:

- Bumper-mounted turret
- Hydro-Chem™ turret and hand line nozzles that discharge a dry chemical extinguishing agent encapsulated in a water/foam solution for greater range and superior fire fighting capabilities
- 66 gpm at 623 psi (250 lpm at 43 bar) high pressure pump



CAS 16 DAEWOO AVIA 4x4 ***typ 3731***









HILLBILLY FIRE

97 freightliner 4 door five man air conditioned pumper
4 scba seats 1500 pump 750 water two crosslays deck gun
Electric ladder rack front suction extended front bumper
Generator & telescopic lights roll up doors 1.5" booster reel federal q siren



80 LN 9000 FORD CANOPY

8v71 detroit diesel,five speed;
1000 gpm 1000 poly tank
Two 2.5" rear discharges
Deck gun



VSAC

- VSAC vehicles can be used for various types of interventions either in places difficult of access, (where reduced dimensions are necessary) such as historical centres, high traffic zones, mountainous areas, or in places where the fire fighting intervention requires water/foam tanks greater capacities.
- Vehicles classification is in conformity with the new European Norms.

ROSENBAUER: MUSTANG CFT

Water tank capacity/material: 10,000 l/glass fibre reinforced plastic sandwich
Foam tank capacity/material: 1,100 l/glass fibre reinforced plastic sandwich
Pump Unit: ROSENBAUER R600 normal pressure pump, rear mounted
Pump output: 6000 l/min at 10 bar
Foam proportioning system: automatic around the pump system ROSENBAUER FOAMATIC RVMA 500
Admixing rate: 3 %, 6 %, 8 %
Front Monitor: ROSENBAUER water/AFFF monitor RM8E, electric remote control with joystick. Output: 950 lpm at 10 bar; Throw range: approx. 42 m
Roof Monitor: ROSENBAUER water/foam monitor RM60E, electronic remote control with pistol grip. Output: 4000 l/min at 10 bar. Throw range approx. 75 m

ARMORED FIRE VEHICLES ON BMP-2 CHASSIS BY MZKT



MZKT has introduced two new models of fire vehicles on BMP-2 Chassis (***LPM-1 and LPM-2)***. Russia has a large number of aging BMP-2 infantry fighting vehicles. At the same time there is a need for fire fighting vehicles that can provide sufficient protection for the crew in the large-scale fires or fires involving hazardous or explosive materials. Somebody put 2 and 2 together and came up with the concept of making fire-fighting vehicles on the chassis of decomissioned fighting vehicles (tanks, armored fighting vehicles and armored personnel carriers).



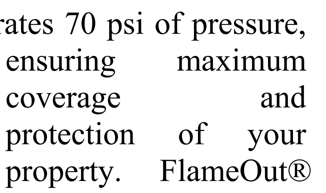
Limitations

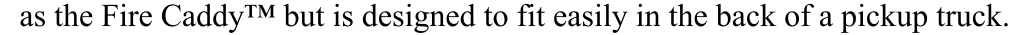
Wildland engines have limitations to their use. They must be properly managed on a wildland fire. Here is a list of six situations that may limit the use of a wild-land engine:

1. Steep or rugged terrain
2. Water supply too far from the fire
3. Incapability of water tenders or other engines to support the engines doing the pumping
4. Fast-spreading fires where the fire intensities are too great
5. Poor access situations where an engine can become trapped, for example, an entry road with large stands of heavy fuel next to the roadway
6. Areas with access problems, such as narrow substandard bridges that could collapse

2.1.2. Pumping equipment

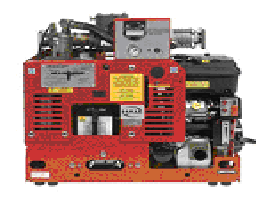
The ***Fire Caddy™*** is the only extended use system that provides exceptional Class A (ordinary combustibles i.e. wood, paper, fabric, etc.) and Class B (flammable liquids) fire suppression. The Fire Caddy™ uses any ready source of water which could include a pond, stream or river, swimming pool, portable water tank, or a buried water tank below frost level. It delivers up to 23 gallons of water per minute mixed with FlameOut® fire retardant foam. The Fire Caddy™ generates 70 psi of pressure, ensuring maximum coverage and protection of your property. FlameOut® is 100% rapidly biodegradeable, environmentally safe and approved by the EPA, FDA, and USDA Forestry Service (specification 5100-307). The ***Wildfire Caddy™*** has the same specifications as the Fire Caddy™ but is designed to fit easily in the back of a pickup truck.





Recently, new and improved engine designs have been produced. Much more powerful than those used so far and allowing for fire-extinguishing agent streams to reach even further and higher (Fig. 1.4) [10].





HALE LTD

These pumps are available in a variety of sizes and capacities to satisfy all field situations and requirements.





Integrated Foam/Portable Pumps HPXV200-B18 and HPXV300-B18

Foam/Pumping Capability

- Compact, very lightweight design
- Configured to installation by truck builders
- Complete with Mini-Manifold and various discharge flange options
- Full instrumentation - Integrated combined instrument panel shipped loose for remote mounting



The integrated V series pump is the newest, most exciting development in slip-on pumps in years. Innovative features have been engineered to provide unparalleled performance of class A foam and a Hale MaxStream series pump.

The MaxStream model configuration is ideal for OEM installation. The pumping unit is attached to a steel skid plate base that can be easily mounted into any vehicle. The rail base includes all required hardware and vibration isolators. The HPXV consists of a HPX200-B18 or HP300X-B18 MaxStream pump married to a Hale FoamMaster 2.5V Foam Proportioning System. An easy to install combination operator panel with on/off control, percentage metering control and priming control on one lever is standard

HP MAXSTREAM DIESEL PUMPS HPX100-BD26



The HPX100-BD26 is ideal for high pressure firefighting applications. It has a high pressure up to 340 PSI and volume flows to 175 GPM. If has a reliable Briggs & Stratton diesel engine and is configured for easy installation by truck builders.

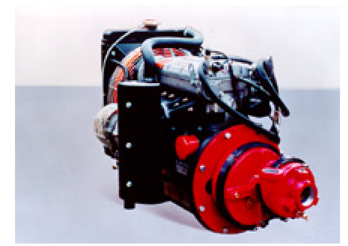
HPX200-BD26



The HPX200-BD26 is ideal for supply and rural fire fighting applications. It offers high volume up to 290 GPM and pressures up to 135 PSI. It comes with a 3-inch NPT female/4-inch Victaulic suction and a reliable Briggs and Stratton diesel engine.

HPX100-LD23

The HPX100-LD23 is designed for high pressure firefighting applications and high pressure fog/long hose lay applications. Pressure applications up to 325 PSI and volume flows up to 155 GPM.



WATEROUS
SILVER SERIES FROM WATEROUS/PNEUMAX



Pneumax Division of Waterous introduces its "Silver Series" PTO-mounted Compressor kits for departments who want CAFS, but would have to wait for improvements in their budgets to afford that purchase. Available in 80, 140 and 200 cfm, these units offer substantial savings over their "Platinum" counterpart CAFSystems™.
Rand – and the price is reflected accordingly.

Model designations for the Silver Series are 80-SP, 140-SP, and 200-SP.

WILDFIRE
PORTABLE 4-STAGE FIRE PUMP MARK-3®



The backpack portable MARK-3® is the strongest performing centrifugal fire pump of this type available. A truly outstanding and reliable performer, the MARK-3® fire pump is designed to withstand the rigors of fire fighting and is easily integrated into any existing operation.
These facts combined with its rugged design features have made the MARK-3® the standard wildland fire pump in North America and in many other countries as well.
MARK-3® shown with optional lightweight backpack convertible frame, C-5201P. This new frame is 2 lbs (0,9 kg) lighter than the standard steel frame.

2.1.3. Fire monitors equipment



Remote monitor operation eliminates the need to have a fire fighter on the deck to operate it. The DeckMaster Monitors provide technologically advanced, electrically controlled and automated elevating capability. Their unique design allows electric elevation and positioning 24" above the base of the flange for operation over obstructions.

ELKHART SCORPION DOUBLE HANDWHEEL DECK GUN



- Efficient 4"(102mm) vaned waterway allows flows up to 1500 gpm/5677 L/min
- Vertical travel from 90º above to 45º below horizontal
- Horizontal travel 360º
- Gears fully enclosed with grease zerks for easy lubrication
- Liquid filled pressure gauge
- Built-in stream shaper

ELKHART SCORPION ELECTRIC REMOTE CONTROLLED DECK GUN



- Efficient 4"(102mm) vaned waterway allows flows up to 1500 gpm/5677 L/min
- Vertical travel from 90º above to 45º below horizontal
- Horizontal travel 345º
- Both gears fully enclosed with grease zerks for easy lubrication
- Liquid filled gauge
- 12V control package includes relay box, primary control box and remote control box

PYTHON® DECK GUN

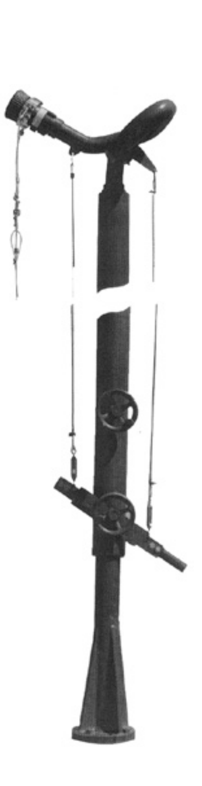


- Full unobstructed 2½"(64mm) waterway allows for flows up to 1100 gpm/4165 L/min
- Stainless steel handle rod controls vertical travel of 90º above to 45º below horizontal
- Full 360º horizontal travel
- Width 18"(457mm), Depth 24"(610mm) Height 24½"(622mm), Weight 45 lbs(20kg)

GIANT PYTHON® DECK GUN

- Stainless steel tubing waterway with cast stainless steel swivel joints
- Full unobstructed 3½"(89mm) waterway allows for flows up to 2000 gpm/7570 L/min
- Stainless steel handle rod controls vertical travel of 90º above to 45º below horizontal
- Full 360º horizontal travel
- Positive twist lock for both vertical and horizontal travel

ELKHART FREE STANDING ELEVATED MONITOR



- A pre-fabricated free-standing elevated monitor which utilizes the flow-efficient "Python" monitor
- Available in 10', 15', 20', 25', 30' and 40' heights
- Flow-efficient, tubular steel riser pipe allows for flows up to 750 GPM
- Tubular steel horizontal drive sleeve allows for continuous 360 degree rotation
- Vertical movement from 45° above to 35° below horizontal is controlled by vinyl coated stainless steel cables
- Two hand wheel driven friction locks allow for stable positioning of the monitor
- 2.5" NHT male outlet and 4.0"-150# or 6.0"-150# ANSI flange base
- Optional CJ-B-RC remote controlled nozzles are ideal for use on these monitors
- Also optional with stream shaper and deluge tip

- Units shipped assembled (25', 30' and 40' units shipped in two assembled sections, each requiring two field welds)
- Finish red acrylic/urethane enamel.

REMOTE CONTROLLED MONITOR



Model WFRRC-1000 monitors are ideal for installation in any high hazard area such as petro-chem plants, offshore platforms or loading docks. Also ideally suited for pumpers, aerials and the remote control monitor can be utilized effectively with limited manpower by placing the controls directly on the pump operator's panel. The WFRRC-1000 remote control monitor comes complete with a 1000 gpm fog nozzle and joy stick control for both 90º vertical and 180º+ horizontal movement. The joy stick has a built-in "butterfly" switch for fog/straight stream pattern control.

- 90º vertical and 180º+ horizontal motion
- AC or DC hydraulic power source
- Joy stick or push button remote control
- Single waterway for minimum friction loss
- 1000 gpm/3785 L/min nozzle
- No gears, chains or racks

SIDEWINDER WILDLAND MONITOR



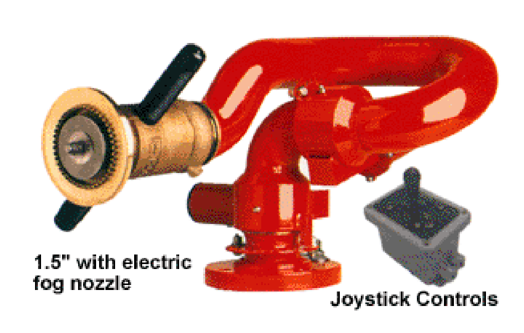
Remotely controlled monitor designed as a front bumper turret monitor to be used in wildland firefighting operations, constructed of durable, lightweight Elk-O-Lite® construction.

- Flow efficient 2"(51mm) vaned waterway
- Three nozzle sizes with flows from 15 to 350 gpm
- Vertical travel 150°, horizontal travel 180° or 334°
- Double ball races with stainless steel bearings
- Constant flow nozzles and manual override
- 12VDC or 24VDC system
- 2"(51mm) female inlet; 1.5"(38mm) male outlet

SNAKE STUMPY WILDLAND MONITOR

The Snake Stumpy remote controlled monitor can be controlled remotely by electric or hydraulic systems. Durable and lightweight, these remote controlled monitors are made primarily of aluminium with fully enclosed stainless steel gears. The control boxes are extremely weatherproof and are suitable to be mounted inside or outside.





They are available in the standard format with 4 toggle switches or with a joystick type control handle with multi-function capabilities.

- 1.5" with control panel and joystick, 50 to 350 gpm @ 100 psi
- 350° rotation, -30° to 50° elevation

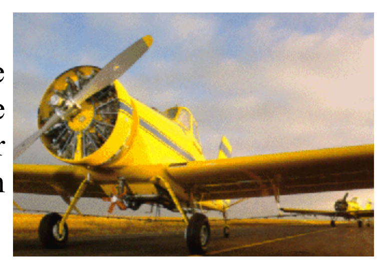
2.2 AIRBORNE MEANS

Aircraft are used to reconnoiter fires, to deliver firefighters, and to drop supplies, retardants, and ignition devices. In general fire agencies recognize two types of aircraft: ***fixed wing (airplane, airtanker)*** and ***rotary wing (helicopter, helytanker)***. Each type has its particular strengths. Within each category aircraft are differentiated according to the payload they can carry.

2.2.1 AIRTANKERS

Fixed-wing aircraft are used for heavy payloads carried over long distances, and for reconnaissance when circumstances require prolonged flight times. Some light aircraft have been adapted for aerial ignition, and others for infrared mapping. Most *air tankers,* or planes equipped to deliver retardant, began as surplus military aircraft, generally of World War II vintage. As the planes have aged, other aircraft of civilian origin, such as the DC-6, have been adapted to aerial attack. One plane, the CL-215 manufactured by Canadair, has been designed specifically for fire control. And one military plane, the C-130, can be outfitted with a modular airborne firefighting system (MAFFS) that carries over 3000 gallons or retardant. Although some planes have special scooping devices that allow them to fill their interior tanks with water from lakes while in flight, most American airtankers require a fixed retardant base at an airport.

AIR TRACTOR AT-401B



The AT-401B is a 400-gallon workhorse powered by the Pratt & Whitney R-1340 radial engine. It incorporates all the rugged durability, safety features, and flying ease that Air Tractors are known for with the low price tag of a piston engine plane.

AIR TRACTOR AT-402



The 402B 400 - gallon turbine utilizes the 680 horsepower PT6A-15AG engine for extra performance and heavier loads

AIR TRACTOR AT-602



The AT-602 is designed for operators who need more than 500 gallons, but less than the 800 gallon AT-802. It only takes one load to spray a 125 acre circle at 5 gallons per acre, and ferry times are shortened by the powerful PT6A-60AG engine. It's the perfect match of hopper capacity to engine performance, and it allows operators to go from a multi-plane to single plane operation for lower overhead and increased profits.

AIR TRACTOR AT-802



The AT-802 series is the world's largest single engine aircraft, and its popularity reflects the industry's trend to larger high-production turbine equipment. Whether it's used for fertilizing forests, spraying huge cotton fields, or spraying dispersant on oil spills, this plane has the productivity and performance to get big jobs done efficiently. Hopper capacity: 800 US gallons

AIR TRACTOR AT-802 F



As the authorized Canadian dealer for the Air Tractor AT-802F, Conair has the knowledge, experience and depth to support this aircraft in Canada. This multiple-use aircraft provides turbine reliability, improved fuel efficiency and heightened aircraft performance for both its initial attack forest fire control and forestry protection roles. Powered by a PT6A-67AG turbine engine, the aircraft is able to takeoff and land at remote strips or small airports and offers low vibration and excellent visibility for the pilot.

- 165 knot cruise speed.
- 4 hour endurance.
- 3,024 litre retardant load (820 US gallons).
- Versatile, multi-purpose aircraft.

CEGISA (CANADA & SPAIN) - FIRE BOSS

The Fire Boss is equipped with Air Tractor's state-of-the-art computer-controlled fire delivery system, enabling pilots to dial in coverage levels and drop volume as a function of ground speed, and to make multiple drops with one load.



The amphibious Fire Boss delivers 5,500 pounds (660 U.S. Gallons) of water payload at 145 knots while burning 80 U.S. gallons of fuel per hour. This means it can remain on the job for more than three hours with the standard 254-gallon fuel tank. Loads can increase up to 6,600 pounds (800 U.S. gallons) as fuel burns off. The ability to scoop water from lakes or rivers extends the aircraft's range and usefulness, since it doesn't need to return to base for re-loading.

LOCKHEED C-130

The C-130 multirole airtanker is a modified version of the standard military Lockheed C-130 aircraft. The C-130 is a high-wing, all metal construction, medium range, land-based monoplane. The aircraft can land and takeoff on short runways and can be used on unimproved landing strips. Four ALLISON T56A-9D turboprop engines of 3750 horsepower each power the aircraft. The engines turn the four bladed Hamilton

Standard 54H60-91 turbopropellers. The aircraft is equipped with a Gas Turbine Compressor/Air Turbine Motor Auxiliary Power Unit to provide for self contained starting capabilities. International Air Responses C-130's are equipped with the **Retardant Aerial Delivery System**, **(RADS)** designed and constructed by Aero Union Corporation of Chico, California for the fire fighting mission. The **RADS** equipped C-130 is the most effective aerial fire fighting tanker in the world. A respected workhorse, this additional capability to be converted to an effective fire-fighting weapon, provides yet another role for this legendary aircraft. The 3,000 gallon tank is a two-part installation with the lower tank permanently installed in the aircraft. The upper tank attaches at the floor line, and can be removed to convert the aircraft back to the cargo configuration; the conversion takes less than two hours to go from freighter to tanker and vise versa. It is designed such that the aircraft can fly pressurized in both tanker and cargo configuration provided the tank is unfilled. Two full-length doors open from the center and are hydraulically operated in unison. They can be closed with retardant remaining in the tank and are designed to produce the maximum shearing and foaming action possible. The system has the ability to maintain constant rates of flow regardless of the level of retardant remaining in the tank. This is accomplished by sensing the level of retardant and constantly adjusting the door opening to maintain the flow rates selected. Various control settings allow for a multiple drop pattern from 1/4 load, full salvo or a continuous line 50 feet wide and almost 7,000 feet long! After dropping part of the load, the system also senses the retardant level remaining in order that the next door opening will provide flow rates consistent with the pattern coverage level selected. Computerized digital control logic enables the pilot to pre-select the coverage level and quantity to produce the desired drop pattern. Drop patterns resulting from **RADS** are continuous and uniform with no overlapping or gaps. The tank is loaded through external ports on either side of the fuselage just forward and below the troop doors by way of three-inch cam loc connectors. Loading time required is 10-12 minutes. This means that turn around time on a typical trip of 100 miles could be accomplished in approximately one hour and ten minutes. The aircraft can drop typical fire retardant, (red slurry) water, or water injected with a foam agent which when dropped covers the fires fuel with an oxygen depriving foam. The aircraft are equipped with dual comm/VOR nav systems, ADF, dual localizer glide slope receivers, GPS, radar altimeter, dual transponders, autopilot, HF radios, and two VHF FM comm radios for air to air and air to ground communications with fire fighting personnel.





- Maximum Gross Weight - 124,200 pounds (56,337 kg)
- Intergral RADS Tank Capacity - 3,000 U.S. Gallons (12,000 ltr.)
- Flight Duration as Air Tanker - 4.5 hours
- Speed as Air Tanker - 230 knots
- Typical Tanker Drop Speed - 120-150 knots
- Typical Tanker Drop Altitude - 125-175 feet AGL

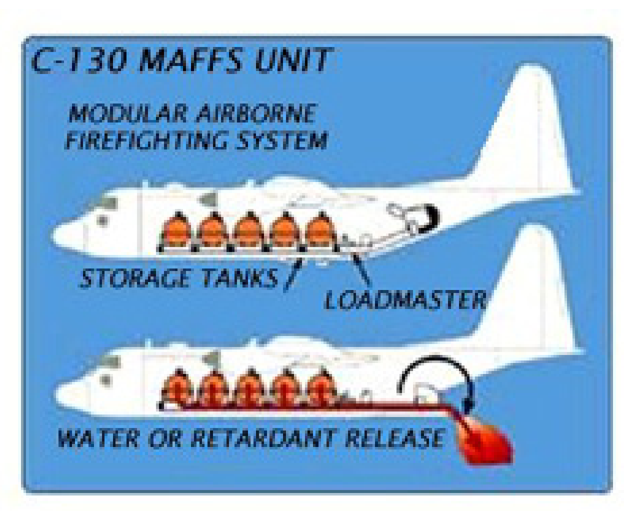
MODULAR AIRBORNE FIREFIGHTING SYSTEM (MAFFS)

MAFFS is a self-contained reusable 3000-gallon aerial fluid dispersal system that allows Lockheed C-130 cargo/utility aircraft to be converted to wildland firefighting airtankers. The system has been used in the U.S., Europe, Africa, and Indonesia. The system is pneumatically powered and includes tank modules, a control module, and a dissemination module. Electrical power is provided by the aircraft or by a 24-volt battery on the control module.



The MAFFS use is a joint program with the Air National Guard, Air Force Reserve, and the U.S. Forest Service; the system was developed for installation in a Lockheed C-130 Hercules plane equipped with the USAF 463L cargo-handling system. Personnel using MAFFS can make variable drops over the fire, with flow rate preselected at the control module. At maximum flow rate, a MAFFS-equipped C-130 can discharge its entire load in under five seconds. Unlike a gravity system in which the aircraft's center of gravity moves aft as the retardant flows to the rear to exit, MAFFS discharges the retardant alternately from a series of tanks to keep the center of gravity within limits. MAFFS-equipped tankers can be re-loaded and flight-ready in less than eight minutes.

Seven tank modules store the retardant under pressure; each module contains a pressure tank where compressed air is stored at 1200 psi. The control module includes the master control panel, the loadmaster's seat, and discharge valves. An air compressor module provides air pressure for charging the system; it stays at the airtanker base during air operations and is used to recharge the system between runs. Each unit weighs about 11,000 pounds, with a load capacity of 2700 gallons.



The units are loaded with either water or retardant - a chemical that inhibits the combustion potential of vegetation on the ground. The retardant contains a fertilizer, and promotes regrowth over the burned area. While water is sometimes dropped directly on a fire, retardant is laid out ahead of the fire or at its edges to inhibit or retard the fire's spread. This allows firefighters on the ground to rapidly take advantage of the retardant effect, which helps in line-building efforts. Its bright red or fuchsia color helps airtanker pilots observe the accuracy of their retardant drops on the edge of the fire.

When the MAFFS units are activated, the assigned MAFFS Liaison Officer (MLO) establishes a loading facility near the fire for incoming tankers. Many variables affect the air drops - including drop height, terrain, wind, fuels, and fire behavior - so the Forest Service has developed various "drop patterns" for the pilot to use during air operations. The drop pattern is determined prior to each run via close radio coordination with the air operations group.



MAFFS Unit on trailor

In accordance with military requirements for initial qualification and recurrent training, MAFFS crews are trained every year with Forest Service national aviation operations personnel. Airports in Colorado were set up as staging areas for this year's annual MAFFS training in May. The U.S. Forest Service and the Colorado State Forest Service coordinated the training with the USAF Reserve's 302nd Airlift Wing at Colorado's Peterson Air Force Base. Also participating were the Guard's 173rd Airlift Wing from Cheyenne, Wyoming, the 146th Airlift Wing from Port Hueneme, California, and the 145th Airlift Wing from Charlotte, North Carolina.

ANTONOV AN-2R

An-2R is specialized agricultural model, with hermetic sealing of the cockpit, revised tail surfaces of greater area, a more advanced propeller, and a fiberglass container for 1960 liters of chemicals or 1350 kg of dust.



CANADAIR CL-215

Air Spray owns and operates the only three privately owned CL-215 airtankers in the world. The CL-215 is an amphibious flying boat which can be loaded with chemical on the ground or it can skim water from a lake in close proximity to the fire.





Air Spray has developed an onboard foam injection system that allows the addition of fire-foam concentrate to the water which increases hold-over time of the fire suppressing capabilities of the water.
The Canadair CL-215 was an amphibian designed primarily for firefighting in Canada, although it was also available to military customers for search and rescue and utility roles. For its fire-fighting role the CL-215 can lift 5455 liters (1440 gal.) of water or retardant fluid in two fuselage tanks. The water is scooped from a convenient lake or river through two retractable inlets mounted under the hull, while the CL-215 taxies across the surface. It then takes off and flies to the area of the fire where the load is jettisoned in under a second. The operation repeated until the fire is under control. In most circumstances a load can be dropped at least every 10 minutes. (Of course, a nearby water source is essential.)

CANADAIR 415 WATER-BOMBER

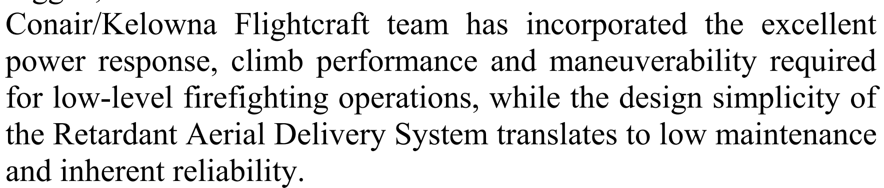
The Canadair 415 Water-bomber carries a water load of 6,123 kilograms (13,500 lbs.) Length 65 feet, wingspan 95 feet and gross weight, after scooping 23,319 kilograms (47,000 lbs). The two Pratt & Whitney turboprops mounted on above wing nacells generate 2380 shaft horsepower each. The first Canadair 415 was deliveried in 1994. This plane with one other, was on loan to British Columbia from Quebec along with her crews. The Quebec crews found the mountains terrain and altitude changes very challenging.



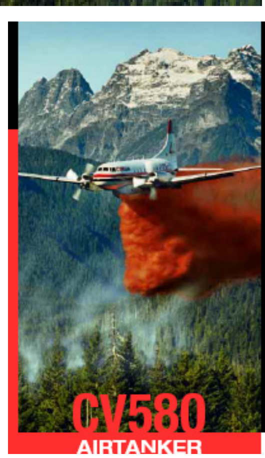
CONVAIR CV 580



One of the best "Initial Attack" aircraft available today, the Convair CV 580 Airtanker was introduced in the 2000 fire season. This aircraft, developed through a working partnership between Conair and Kelowna Flightcraft, offers economy, high speed and reliability with its Allison 501 D13 powered turboprop twin engines. The aircraft promotes safety with the modern IFR capable cockpit and simple engine handling, allowing outstanding pilot visibility required for rugged, mountainous terrain. The



Conair/Kelowna Flightcraft team has incorporated the excellent power response, climb performance and maneuverability required for low-level firefighting operations, while the design simplicity of the Retardant Aerial Delivery System translates to low maintenance and inherent reliability.



- 270 knot cruise speed
- 4 hour endurance
- Turbine power for rapid dispatch
- Optional under-wing pressure re-fuelling
- Single port retardant loading / 5 minute retardant tank fill time
- 7,955 liter retardant tank capacity (2,100 US gallons)

- Constant flow variable volume retardant delivery for uniform coverage

CONVAIR CV 5800

The Convair CV 5800 Airtanker is the next generation aircraft to the CV 580 with an enhanced load capacity making it an invaluable fire management tool for protection agencies across North America, and around the world. This aircraft maintains all of the operating characteristics of the CV 580 including economy, high speed and reliability with its Allison 501 D22 powered turboprop twin engines. The aircraft also promotes safety with the modern EFIS IFR capable cockpit and simple engine handling, allowing outstanding pilot visibility required for rugged, mountainous terrain. As well, the superior maneuverability features characteristic of the CV 580 - - excellent power response, climb performance and maneuverability required for low-level firefighting operations, and design simplicity of the Retardant Aerial Delivery System have all been maintained to make this a low maintenance, reliable fire management tool. The conversion process of the CV 5800 undertaken by the Conair/Kelowna Flightcraft team has incorporated an expanded load capacity enabling this aircraft to carry up to 10,400 liters.



- 280 knot cruise speed
- 4 hour endurance
- Turbine power for rapid dispatch
- Dual point under-wing pressure refueling
- Single port retardant loading / 6 minute retardant tank fill time
- 10,400 liter retardant tank capacity (2,750 US gallons)
- Constant flow variable volume retardant delivery for uniform coverage

DOUGLAS B-26 INVADER

B-26 is equipped with a 1000 U.S. gallon tank for holding fire retardant. The planes are dispatched in groups of 3 or 4 along with a birddog aircraft. They are placed at airstrips which are in close proximity to the forest fires. The high cruising speed and large tank capacity of the Douglas B-26 make it an ideal aircraft for fighting forest fires. The plane's high degree of maneuverability makes it an effective fire-fighting tool in the mountainous regions of Western Canada.



GRUMMAN CS2F-1 TRACKER

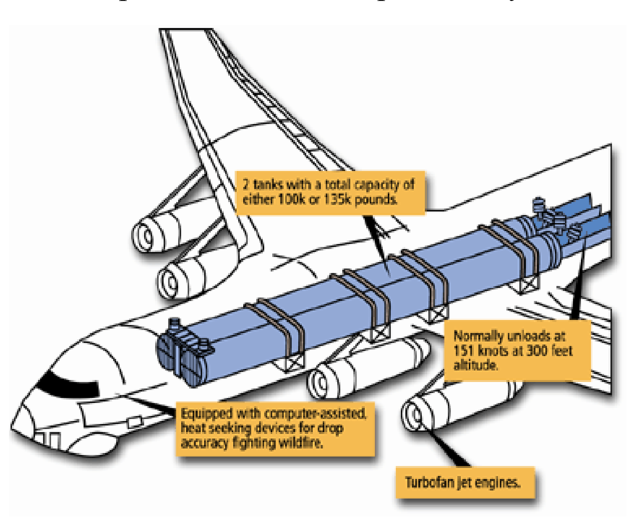


Formerly the Grumman CS2F-1 Tracker, (Canadian forces) a Navy plane, Conair has converted these into a valuable fire fighting plane. Now renamed the Conair Firecat.
Maximum take-off weight; 13,222 kg. (29,150 lbs.); Maximum level speed 426 km/h. (265 mph.)

IL-76

World's Fastest, Longest-Range, Highest-Volume, Air-Tanker.

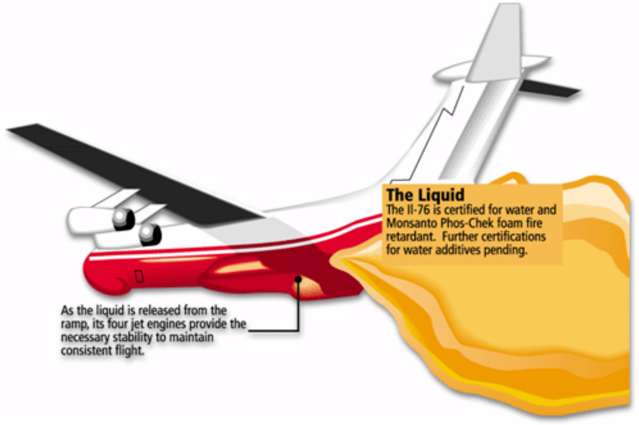
The IL-76 turbofan jet cargo aircraft is by far the world's most formidable, fastest, longest-range, air tanker. For fire fighting and ocean oil spill dispersal, as well as for dispersion on (e.g.) chemicals plants in upset conditions, it comes outfitted with a twin-tank system capable of carrying either 100,000 or 135,000 pounds of liquid and can be filled and ready for takeoff in 15 minutes. In its smaller 100,000 pound version, this patented system is capable of depositing more than 3,608-3,937 ft x 263-295 ft of liquid in one 8-10 second pass - water only - and one 15-20 second pass with foam additive. This is up to five (5) times greater than the volume deliverable by the largest-volume "water bomber" commonly used in the world today.



An IL-76 can also offload its twin tanks in a single salvo, yielding a smaller, heavier, saturation drop pattern for use on particularly hot or powerful blazes or other special situations.

The aircraft is equipped with heat-seeking devices and associated computer-driven fire data simulations providing assistance with aiming the drop for maximum effect on mass fire.

In fire fighting, liquid drops are normally delivered at a speed of 151 knots at 300 feet altitude. Liquids descend vertically, as rain, evenly penetrating forest canopy, thereby optimizing the fire-retarding effect on the forest floor.



Liquids mixes certified for use with the aircraft by Ilyushin Design Bureau, include Monsanto PHOS-CHEK WD 881. Prospects for certification for

slurry use are excellent.

A fully-integrated emergency service complete with spares and certified EMERCOM crew for fire fighting, humanitarian relief, and disaster mitigation and prevention stands ready for emergency deployment. Emergency availability is managed on a 48-hour, best efforts call-out basis. Plans for radialogical disaster prevention are also offered

LOCKHEED L-188 ELECTRA

The L-188 Electra Long Liner is presently the fastest initial attack air tanker in service today. It is fast during initial dispatch with no required warm up time, it cruises at 380 MPH and its maneuverability makes it the fastest large air tanker while working over a fire.



The L-188 Long Liner is equipped with the Air Spray Constant Variable Flow Tank System. The Constant Variable Flow Tank System is an entirely new computerized system which consists of a single 3000 US gallon tank, with a computerized door. The system can string out a "long line" or drop its entire 11365 liters in under 3 seconds. The system is so precise it can deliver any volume, coverage level or line length exactly as requested with a simple turn of a switch at the pilots finger tips! The Constant Variable Flow System produces a longer stronger line of retardant or foam since there are no weak spots created by multiple door drop sequences.

AIRCRAFT FLEET - "THE MIGHTY MARTIN MARS"

The plane can be in the air in ten minutes and can make a drop every fifteen minutes. Working in tandem, this equates to 7,200 US gallons (27,276 litres) every seven minutes and each drop can cover an area of up to 4 acres (1.6 hectares). It has often been said that the Mars, with a 60,000 pound (27,216 kilogram) payload of foam, is like "hand-grenades or horseshoes - close is good enough" but such is not the case.



Each Mars carries 600 US gallons (2,270 litres) of foam concentrate - enough for 21 drops of a 0.4% solution which is the standard used although it may be decided to use more or less foam as dictated by the Fire Boss.

Flying Tankers completed test and evaluation of Class A foam in 1986 and began using it with the Mars as a matter of routine in 1987. It has been estimated that the foam capability of the aircraft increases the efficiency of the Mars by at least 30%. The ability of the machines to drop massive amounts of foam lends itself particularly well to the suppression of urban/rural interface fires and the Mars have excelled in this regard.

BERIJEV BE-200 P



The Be-200 is a multipurpose amphibious aircraft of which configurations are available for fire fighting, passenger, and cargo transport. The two D-436 turbofan engines are top-mounted and allow the scooping of water for aerial delivery over forest fires at wave heights of up to 1.2 m. In addition to the capacity of 12 tons of water (or retardants) a 1.2-m^3 tank for liquid chemical is installed on the aircraft.

DOUGLAS DC-7 TYPE I

The DC-7 is a converted civilian airliner with a retardant capacity of 3000 gallons. The DC-7 can be distinguished from the DC-4 and DC-6 models by square windows, with three being forward of the wing (DC-4 has round windows), and four-blade propellers (DC-4 & DC-6 have three-blade propellers).

LOCKHEED P2V5 - P2V7 NEPTUNE TYPE II

The Lockheed P2V-5 and -7 models were used extensively by the Navy as long-range over-water patrol and anti-submarine warfare aircraft. The P2V has a mid-wing with reciprocating (piston) engines and jet engines. The jet engines burn the same fuel as the piston engines (AV-Fuel) and are used primarily for take-off assist and during the drop sequence.

AIRBORNE FIREFIGHTING SYSTEM (AFFS)

Airborne Firefighting System (AFFS) is the next-generation roll-on, roll-off firefighting system designed to air-drop fire-retardant chemicals used in fighting forest fires. AFFS is an integral tool for battling large wildfires. AFFS is the newest firefighting system and is a fully integrated and fully self-contained system that employs an on-board compressor system replacing the ground support equipment requirements of the MAFFS unit. A self-contained compressor saves valuable time and money by eliminating the necessity of ground support compressors.



MAFFS II

Carbon fiber retardant tank and cradle. This tank holds 3600, 4000, or 4300 gallons depending on C-130 model aircraft.

AFFS will replace firefighting equipment that the Air National Guard and Reserves have used in its C-130's for thirty years.



Installing nozzle and hydraulic pack. This nozzle is installed after tank and compressors. Pressurization door is then installed. Total time to convert from cargo to retardant configuration is less than 4 hours.

The AFFS system can carry 3600, 4000, or 4300 gallons depending on the C-130 model aircraft. AFFS employs a positive-feed, pintle-valve delivery system and leading edge composite technologies. Engineering designs also have reduced the amount of retardant splashed on the exterior of the plane during aerial drops, which saves time and money previously allocated to cleaning the corrosive retardant from the plane.

HELYTANKERS

Increasingly ubiquitous, however, are helicopters. They can be used to reconnoiter, to haul supplies and firefighters, to drop retardant, lay fire hose, and deposit incendiaries in a variety of ways. Special night-vision glasses make evening flights possible. A few places have added the technique of rappelling from a hovering helicopter (helirappel) to assist initial attack. More common is the use of medium-sized helicopters to quickly transport large numbers of firefighters, and a natural alliance has evolved between them and IHC crews. As a means of delivering retardant or water, the great virtue of the helitanker is its accuracy; its limitation, small payloads, can be overcome by the establishment of portable retardant bases conveniently placed near the fire.

SIKORSKY S-64 SKYCRANE TYPE I HELICOPTER

The S-64 can carry a incredible amount of cargo, so it's natural that it was adapted to carry water or retardant for firefighting. This very versatile Aircraft can suck water into it's 2000 gallon tank via snorkel, or land to be loaded with retardant. the fixed tank on the S-64 Aircrane conforms to the same criteria as tanks installed on fixed wing aircraft. The computations and planning involved with Airtanker drops can be applied to the Helitanker. Considering the fast refill time of 45 seconds or less in any water source as shallow as 18 inches. We've seen a number of these Helicopters this year in Colorado.



ERICKSON S-64 AIRCRANE HELITANKER

The Erickson Air-Crane Helitanker is the most versatile, powerful, and cost effective aerial fire suppression system in the world. Since certification in 1992, the Helitanker has seen worldwide service, fighting fires in the United States, Canada, Mexico, Borneo, Italy, Greece, France, Turkey, and Australia.







A ram scoop hydrofoil allows the Helitanker to refill from fresh water and sea water sources in less than 45 seconds.

A flexible hose snorkel features a high pressure impeller and can draw water from any water source 18 inches (45 cm) or deeper as fast as 45 seconds.



The 2,500 gallon (~9,500 litre) tank drops water, retardant, or foam mix. Microprocessor controlled tank doors offer eight individual coverage level options.

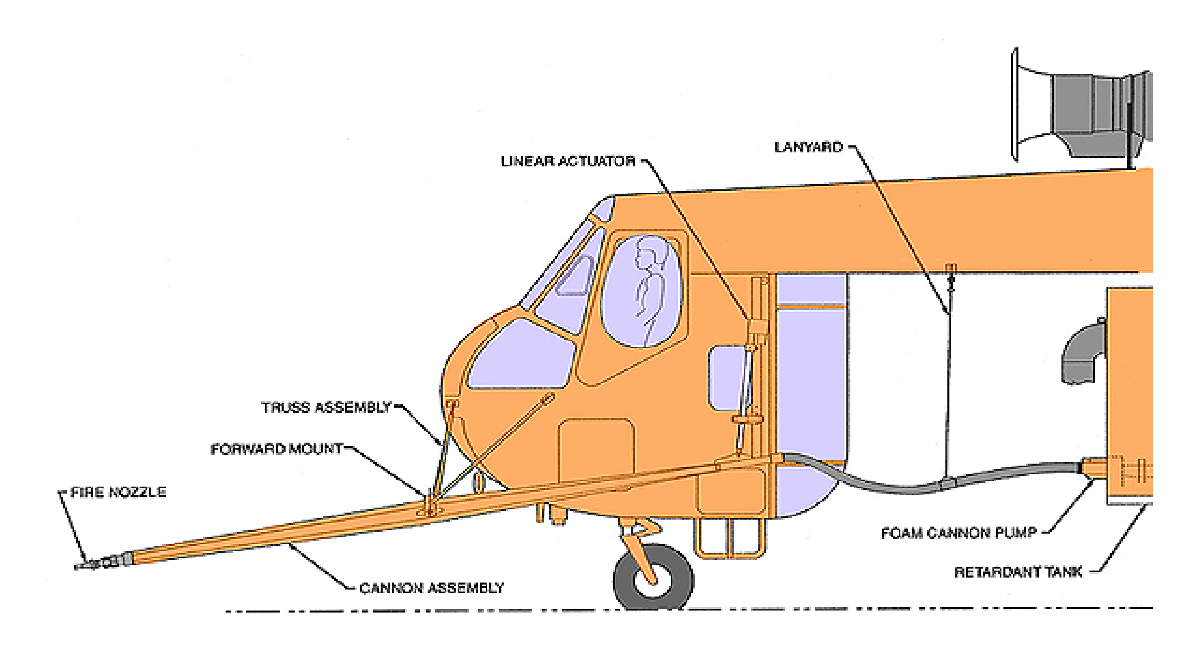
In April of 1998, The Federal Aviation Administration certified a long slender horizontal nozzle attachment for use with the S-64 Aircrane Helitanker. Affectionately dubbed "The Water Cannon", this high powered piece of fire suppression equipment is destined to change the direction of wildland, urban interface and high rise structure fire suppression.



The Water Cannon is nozzle attachment mounted to the forward left side of the Aircrane capable of tilting up or down for increased control of the water stream. Connected to the 2,500 gallon (~9,500 litre) tank, the Water Cannon delivers a horizontal stream of water or foam mix up to 160 feet (~49 m) at a rate of 300 gallons (~1,140 litres per minute). With a full water tank, the cannon system is capable of maintaining the 300 gpm (~1,140 lpm) flow for up to eight minutes.

The Water Cannon was developed from a single simple idea: to get a high intensity stream of water or foam mix into a variety of inaccessible areas threatened by fire or burning. The cannon is seen by many to be an effective tool in fighting high rise structure fires. With the Water Cannon, the Helitanker can hover outside the burning section and direct a constant stream of water or foam mix into and around the blaze.

With eight minutes of constant flow, it is possible to suppress dangerous fire blowouts and prevent lapping. With the proper foam mix, the Helitanker Water Cannon can stabilize the critical heat coefficient and cool the load bearing members of the building to prevent collapse.



The Water Cannon can also be used to suppress flammable liquid fires with a special AFFF (Aqueous Film Forming Foam) foam mix. When tank vehicles, or even refineries are threatened, the Helitanker can use the cannon to direct a stream of water or foam into the more hard to reach places.

The Erickson S-64 Aircrane Helitanker is built by attaching a 2,600 gallon (9,800 litre) firefighting tank system to the fuselage of the S-64 Aircrane. The tank system consists of a high volume "Hover Snorkel" that can fill the tank in 18 inches (45 cm) of water within 45 seconds. **A special "Sea Snorkel", designed for the tank, augments the freshwater hoverfill capabilities of the hover snorkel** by allowing for 45 second refill in nearby saltwater sources. The doors of the tank are controlled by a microprocessor that adjusts for the groundspeed of the helicopter to deliver 8 different coverage levels of water, foam mix, or retardant. The pilot selects a coverage level from 1 gallon per 100 square feet to 8 gallons per 100 square feet. (~4 liters per 10 sq meters – ~30 liters per 10 sq meters) If required, the pilot can dump a salvo of the entire 2,500+ gallon (9,500+ liter) load in less than 3 seconds.

MI-14, 1000 U.S.GAL. HELITANKER

The Mi-14 helicopter, a proven design developed by Mil Aircraft, has been fitted with an internal tank having a capacity of 1,057 US gallons, by Aerotech GmbH.



Fire Fighting System:

- Water Capacity: 1,057 US gal.
- Foam Capacity: 105 US gal.
- Hover Refill Pump: Single or Dual Hydraulic

- Pump Capacity: 800 GPM (per pump)
- Hover Refill Time: 80 Sec. - Single
  40 Sec. - Dual

KA-32, N.I.KAMOV 'HELIX'



*D*evelopment of the Ka-27. It is designed for firefighting operation from tropical latitudes to the Polar Seas under humid (and salty) ocean conditions. The Ka-32 is equipped with de-icing system for cockpit glazing, engine intakes and rotor blades.
The basic Ka-32 is equipped with 3000 l in belly tank.

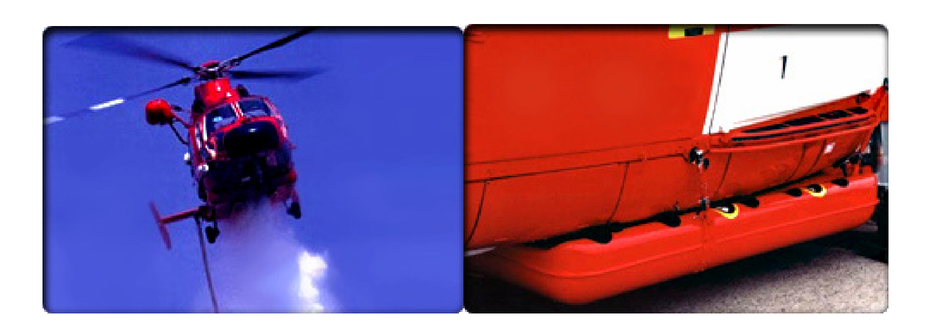
S-70A FIREHAWK



An S-70A Firehawk can refills its underbelly tank using its snorkel hose. The aircraft is able to refill its 1,000-gallon tank in about 60 seconds via this method.

MODEL 301 FIRE ATTACK EUROCOPTER AS365 SERIES

Water Capacity:	238 US gallons (900 lt)
Retardant capacity:	24 US gallons (90 lt)
Hover refill pump rate:	320 GPM (1212 lt/min)

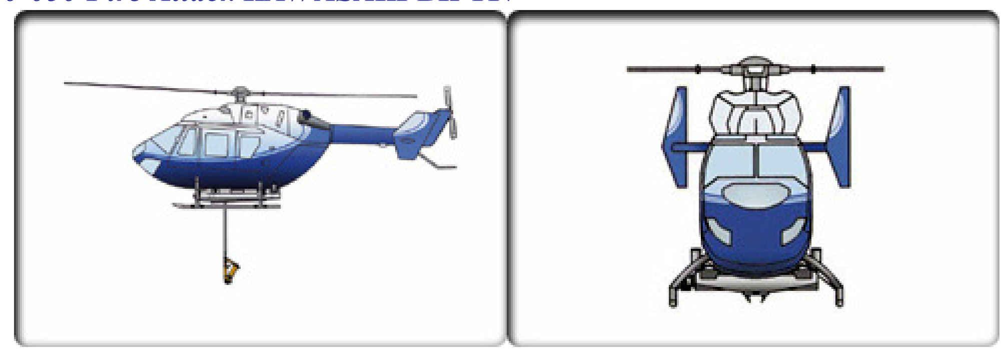


MODEL 304 FIRE ATTACK BELL UH-1H, 205, 212, 412 SERIES

Water Capacity:	375 US gallons (1420 lt)
Retardant capacity:	36 US gallons (143 lt)
Hover refill pump rate:	320 GPM (1212 lt/min)



11100-050 Fire Attack KAWASAKI BK-117

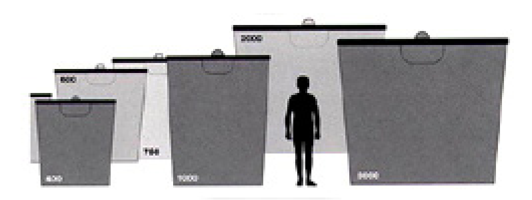


Water Capacity:	177 US gallons (670 lt)
Retardant capacity:	20 US gallons (78 lt)
Hover refill pump rate:	320 GPM (1212 lt/min)

19000 BIG DIPPER SERIES CARGO EQUIPED HELICOPTERS



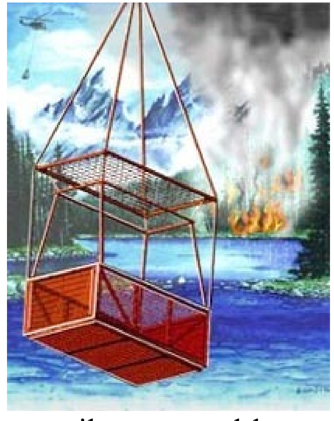
The Big Dipper is a family of helicopter slung aerial firefighting buckets that have been long recognized as the most rugged, versatile, and cost effective system for firefighting. The Simplex systems are collapsible, rapidly deployable, dependable, durable and easy to operate. With more than fifteen years of field testing under actual wildland fire conditions, the Big Dipper Firefighting Bucket System has proven its effectiveness and capability worldwide.



Heli-Basket External Load Transport System

The Heli-Basket is carried as an external load by a helicopter with sufficient power and lift capability. The pilot uses standard military external load procedures or vertical reference to lift and land the Heli-Basket.

All helicopters with an external load lifting capability of 5100 lbs. are able to maximize the use of the Heli-Basket. This includes the Type 1 helicopters listed by the Inter-Agency Fire Aviation Center in Boise, Idaho (see link below). The empty Heli-Basket and its rigging weigh 600 lbs. The maximum load of cargo that can be carried in a standard Heli-Basket is 4,500 pounds. Smaller helicopters may be able to carry smaller loads.



An Abbreviated List of Rotorcraft Manufacturers: Sikorsky, Bell, Kaman Aerospace, Eurocopter, American Eurocopter, Boeing, Agusta, AgustaWestland, Westland, MD Helicopters, Vertical Aviation Technologies, Erickson Aircrane, Kamov, Mil, Hindustan

For transporting equipment, such as the Fire Fighting Module, in the Heli-Basket, the standard configuration includes a pilot-operated lower load hook (remote hook) and a long line or cable with electrical conductors. This allows

the pilot to land the loaded Heli-Basket at places where there is no ground crew on site, disconnect the Heli-Basket, and perform other functions. The belly strap is not needed when there is no live load.
For typical applications in which the Heli-Basket will be stored in a hanger for much of the time and the use is land-based, the standard powder coat finish is appropriate. For marine applications, a marine-grade finish is available.

- Work area: 137cm x 259 cm
- Work volume: 3.22 cubic meters
- Empty weight: 272 kg
- Pay load: 2045 kg
- System weight (incl. long line and heli-strap): 301 kg
- Gross weight (incl. pay load, long line and heli-strap): 2342 kg
- Height of system when suspended: 4.6 m

The heli-basket is complete and ready to fly with multi-purpose spreader bar, tie-down straps, safety net and cabling.

SEI INDUSTRIES INTERNATIONAL INC.: BAMBI BUCKET



The Bambi Bucket® is a proven, helicopter-borne integrated firefighting system in service worldwide. Lightweight, tough and easily stowed, the Bambi Bucket has proven itself as the most powerful and effective weapon for aerial fire suppression work. This foam compatible bucket system includes an outward opening dump valve, which allows a solid column of water or foam to be dropped on targets with absolute precision.
A helicopter with a Bambi Bucket is an efficient, independent fire-fighting vehicle. It creates the opportunity to put more water on the fire than any other system, at less cost.

- Pilot controlled dump patterns
- Eighteen sizes available: 72 to 2,600 U.S. Gallons (275 to 9,840 liters)
- Exclusive outward opening fabric dump valve made of foam-resistant material. The resulting column of water generated allows the pilot to drop from a higher altitude thereby reducing downwash and pilot risk
- The Instant Deployment System™ (IDS) ensures rapid set up; the Bambi Bucket is deployed simply by removing it from the carrying bag, attaching the control head to the cargo hook, and attaching power. As soon as the weight of the Bambi Bucket is taken by the suspension lines, it instantly deploys.

SACKSAFOAM™ INJECTION SYSTEM



The versatile Bambi Bucket is available with the optional Sacksafoam™ foam injection system that increases the effectiveness of each water drop by a multiple of 600 - 1500%. This model is designed with the foam dispensing unit located inside the Bambi Bucket itself and the Sacksafoam control unit located in the cockpit. Ideal for smaller buckets.

HEAVY LIFT BAMBI BUCKET

The new Heavy Lift Bambi Bucket was essentially redesigned, with detailed analysis of every component.

Model	Capacity		
	Imp. Gal	US Gal	Litres
5566HD	550	660	2500
6578HD	650	780	2955
7590	750	900	3405
HL5000	1100	1320	5000
HL7600	1665	2000	7570
HL9800	2165	2600	9840



TWIN HEAVY LIFT BAMBI BUCKET®



The Twin Heavy Lift Bambi Bucket is the newest and biggest addition to the Bambi Bucket line. This model has a combined payload of 20 tons (19,600 litres/5200 USG) and has been successfully tested and flown under a Mi-26T.
The focus in forest fire-fighting is for an early attack, taking command of the fire before it gets out of control. The trend is to use larger helicopters to transport a skilled ground crew and their equipment directly to the remote incident, then quickly change roles to provide aerial delivery of fire suppressant. This tactic takes full advantage of the helicopter's multi-mission capability. In this scenario, the Bambi Bucket equipped heavy lift helicopter is a proven asset.

ERICKSON DOWNUNDER LLC SLING TANKS

The advantage to the operator is more time on the fire and less things to go wrong.

Variable capacity

This feature allows the pilot to automatically and accurately adjust the amount of water being lifted in flight. Thus removing the need to land and make adjustments. From the cockpit with a simple dial adjustment, the pilot selects the desired level from 100% to 40% of system capacity. This not only improves safety but allows the helicopter to remain on the fire longer as more fuel can be loaded initially. As fuel burns off, more water can be added to the SLING TANK When operating at high altitudes, this feature greatly improves the safety and efficiency of the mission.

Emergency attachment points



The SLING TANK is fitted with four, 500lb/230kg emergency attachment points at the bottom rim of the reservoir assembly. In an emergency the empty SLING TANK can be used as a transport vehicle to extract a variety of loads from an approaching fire front. Loads can

either be attached with karabiners directly to the attachment points, or due to the solid floor, they can be placed inside the reservoir assembly for transport.

Collapsible The flexible walls of the SLING TANK reservoir assembly allow it to collapse vertically. The upper spokes allow the top of the shell to collapse radially to the diameter of the solid base. The SLING TANK can then fit into a sausage bag for transport inside the baggage compartment of the helicopter..



Without requiring complicated systems, SLING TANKS are user friendly, lightweight and encompass a wide variety of features previously found only in the more expensive fixed systems.

The SLING TANK uses no electric motors, pumps or bleed air systems. There are no purse strings, and no electrical relays to breakdown. Likewise, the SLING TANK foam injection system uses no electric motors or pumps, which means no breakdowns.

Multiple drop

The pilot controls the dump valve in the open or closed position. By simply opening or closing the SLING TANK valve, water will flow or cease flowing from the SLING TANK Environmentally sound foam injection Foam concentrate is injected into the outward flow of water at the base of the SLING TANK. This eliminates any foam residual from contaminating sensitive water areas. A unique foam dispensing system allows for a correct foam/water mix without the foam concentrate ever being dispensed into the SLING TANK itself. Many fire agencies world wide now do not allow the use of foam because of environmental concerns. The SLING TANK solves this problem.

Construction / Design

The SLING TANK shell is constructed from a two-ply flexible material and further reinforced with weldable webbing sandwiched within the plys. There are between 8 and 32 vertical straps connected to the shell depending on the size of the system, giving it a X 10 standard weight rating; a SLING TANK system capable of a gross weight of 1,000 kg will have a breaking rating of 10,000 kg for the shell material alone. Additionally, the shell incorporates three horizontal bands to prevent expansion of the shell when filled.

The SLING TANK reservoir assembly is suspended from four cables each having a X 4 working load rating and a X 6 snap load rating. The valve control cable provides additional support and automatically dumps the water load should a main cable break, removing the weight from the system in the event of a catastrophic failure.

An added system feature is a cushioning valve in the actuator, which dampens the effects of the valve opening to significantly reduce or eliminate the effects of "hook shock".

IFEX TECHNILOGIES: THE FIRECOPTER

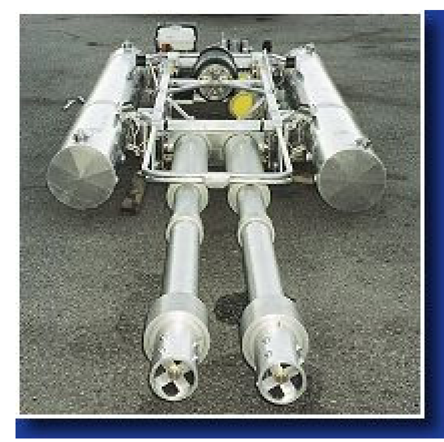
Forest, bush and wildland fires do occur frequently in inaccessible areas where the transportation of equipment and water supply is a difficult operation. While conventional technology uses airplanes and helicopters equipped with water buckets to drop the agent over the area on fire, the IFEX impulse fire extinguishing technology - mounted onboard fast and versatile helicopters - needs only small amounts of water to control and suppress the fire or prohibit it to propagate into other areas.

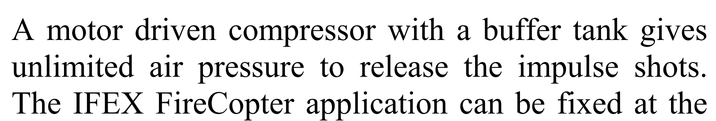


A similar problem for firefighters worldwide are fires in high rise buildings within city areas. Limited height of fire ladders and hydraulic booms makes the fire extinguishing process difficult and in many cases impossible. Utilizing the same application as for forest fires, the IFEX helicopter extinguishing gear presents the optimum solution and application for these situations.

The Firecopter Skid

The extinguishing tool onboard the FireCopter skid is the IFEX 18 liter Dual Intruder; the high performance dual cannon with the necessary shot range, momentum and flux density to allow immediate control of the fire from a distance. The water supply is carried by two water tanks with extra additive tanks; more than 300 liters allow for a long and efficient field duration. Refilling can be done easily while airborne.





A motor driven compressor with a buffer tank gives unlimited air pressure to release the impulse shots. The IFEX FireCopter application can be fixed at the helicopter's cargo slinghook and stabilized at the landing gear within a few minutes. The skid can be adapted to various models of helicopters upon request.

Airborne Initial Attack

The IFEX FireCopter skid offers a significant contribution to conventional fire extinguishing technology and practice. It can be attached to different types of helicopters. With its high speed and independence from a supply infrastructure the FireCopter is the ultimate solution for an initial attack on any industrial or residential fire. The IFEX equipped helicopter is able to carry a three men crew plus their extinguishing gear.



The cannon tilt mechanism is easily operated by the pilot or copilot, with the impulse shot being triggered directly from the flight stick. A well trained pilot will easily be able to place his shots directly into the seat of the fire without any water spillage. For special

operation requirements the helicopter will be equipped with an additional camera targeting system.SYSTEM ADVANTAGES

- Quick installation and removal - in less than 5 minutes
- Ready to shoot as soon as airborne
- 18 liter cannons with 60 meters range (optimum at 40 meters)
- Able to shoot any liquid agent (water, foam additive, retardant etc.)
- No water source required at the fire location
- Fast cannon recharge time (2 to 3 seconds)
- Fast and easy water refilling while **airborne**

water capacity	2 x 155 liters
weight (without water)	350 kg
length x width x height	2960 x 400 x 200 mm
material cylinders and frame	Aluminum AL 52
operating pressure	25 bar
speed of agent discharge	120 m/sec
high-speed valve opening time	20 milliseconds
water shot range	up to 60 meters
width of water shot spray	from 4 to 7 meters
effective extinguishing distance	up to 40 meters

2.3 Literature search for forest fire suppression equipment: Fire-fighting systems and equipment

Work that has been done:

- Determining search aims, objectives and approach;
- Literature search;
- Defining key words and phrases;
- Performing search for finding the Web Sites of Organisations, Departments, Specialists and their Email addresses that are of interest for current work;
- Sending enquiry letters;
- Specifying criteria for results selection and structuring;
- Performing Internet Search and selection;
- Classification of the results.

The aim of the performed Search has been to:

1) Acquire information on the level of innovative thinking in the area of forest fire fighting methods and systems;
2) Find out interesting individual principles that are applicable to the specific area of research;
3) Establish contacts with researchers, that work in similar areas.

2.3.1 Approach

- ***Sources Search:***

Literature search was carried out in various catalogues available from libraries, book stores and Internet sites using key words. Headings and brief resumes included in the catalogues have been searched for available key words. All references to books, reports and articles have been reviewed and additional sources from them have been selected, corresponding to specific key words of our field of interest.

Internet search has been carried out using specific key words and the following sites were searched using Internet Search Engines: fire organizations, fire departments, universities, fire research centers, government agencies, companies, etc. as well as any links they provide to similar sites. The following key words and phrases were used as key words for Internet searching: "fire fighting system", "forest fire equipment", "fire fighting equipment", "fire fighting apparatus", "fire fighting tools" and "fire extinguishing systems", "fire fighting vehicles", "fire apparatus", "suppression equipment".

- ***Contacts Establishment:***

Establishing contacts and using them to acquire various pieces of information was carried out based on some of the selected Internet results – sites of fire organizations, fire departments, universities, fire research centers, government agencies, etc. Among them, persons holding various positions of reference to the field of interest were selected and their email addresses were found. Thematic specialized search was also carried out using specific names of researchers and products found as a result of the literature search carried out above. An information enquiry letter was prepared and sent to various addresses. Some of the contacts established re-directed me to other specialists involved in field of interest. A large portion of all replies contained references to specific Internet sites.

The list of all established contacts is indicated in Appendix 2.

- ***Selection of the results***

Results were subjected to double-stage systematization:

  - a primary selection of results,
  - a secondary result classification stage.

An initial analysis was carried out during this systematization procedure to establish compliance between source contents and the topic of the survey and the degree of compliance was also indicated.

The method involved a review and specific search for information relating to fire fighting systems, methods, machines and equipment. This was carried out by means of an initial analysis of source attributes (depending on source type – a book, report, brochure, Internet site, etc.) observing a particular sequence of operations: review of heading, contents review, summary review, introduction review, text review, pictures review, etc. The results of the search were selected based on an assessment for compliance with the field of interest.

- ***Classification of the results***

Classification was carried out based on general principles that classified results in several groups.

2.3.2 Results

The initial analysis helped classify results in two basic groups: Ground and Airborne means of fire fighting, and each of these groups was divided into a number of sub groups.

Primary Databases

a. <u>Literature:</u>

1. ERTEL, M. and BERK, G., 1998. *Firefighting: Basic Skills and Techniques*. (s.1.): Goodheart-Willcox Co;

2. LOWE, J.D., 2001. *Wildland firefighting practices.* Albany, NY: Delmar.

3. JOHNSON, E., 2001. *Forest Fires: Behavior and Ecological Effects.* (s.l.): Academic Press.

4. GOODSON, C., ed., and ADAMS, B., ed., 1998. *Fundamentals of wildland firefighting.* 3rd ed. Stillwater, Oklahoma: Fire Protection Publications, Oklahoma State University.

5. PYNE, S.J., ANDREWS, P.L., and LAVEN R.D., 1996. *Introduction to wildland fire*. 2-nd ed. (s.l.): John Wiley & Sons.

6. PYNE, S.J., 1997. America's fires: management on wildlands and forests, Durham, NC: Forest History Society.

7. FULLER, M., 1991. Forest Fires: An Introduction to Wildland Fire Behavior, Management, Firefighting, and Prevention (Wiley Nature Editions). (s.l.): John Wiley & Sons.

8. BROWN, A.A. and DAVIS, K.P., 1973. *Forest fire: control and use*. 2nd ed. New York: McGraw-Hill.

9. MACLEAN, J.N., 1999. *Fire on the mountain: the true story of the South Canyon fire.* New York: William Morrow.

10. TEIE, W.C., 1994. *Firefighter's handbook on wildland firefighting: strategy, tactics, and safety*. Rescue, California: Deer Valley Press.

11. QUEEN, P.L., 1993. *Fighting fire in the wildland/urban interface*. Bellflower, CA: Fire Publications, Inc.

12. PERRY, D.G., 1989. *Managing a wildland fire: a practical perspective*, Bellflower, CA: Fire Publications.

13. PERRY, D.G., 1987. *Wildland firefighting: fire behavior, tactics & command*. Bellflower, CA: Fire Publications, Inc.

14. CHANDLER, C. et al, 1983. *Fire in forestry*. New York: Wiley.

15. CORBIN, G.O., 1975. *Air operations for forest, brush, and grass fires*. 2nd ed. Boston, Mass.: National Fire Protection Association.

16. GAYLOR, H.P., 1974. *Wildfires: prevention and control*. Bowie, Md.: R.J. Brady Co.

17. OMI P.N., 2004. *Forest Fires: A Reference Handbook (Contemporary World Issues)*. (s.l.): ABC-CLIO.

18. State of New York, Department of State, Office of Fire Prevention and Control, 1989. *Grass, brush & forest fire fighting: workbook*. Albany, N.Y.: The Office.

19. United States. Forest Service. Manual for forest fire fighters. [n.p. G.P.O. n.d.]

20. WIEDER, M., ed., SMITH, C.M., ed., and BRAKHAGE, C., ed. 1996. *Principles of Foam Fire Fighting*. 1st ed. Stillwater, Oklahoma: Fire Protection Publications, Oklahoma State University.

21. LINVILLE, J.L., managing ed., et. al., 1991. Fire protection handbook. 17-th ed. Quincy, Massachusetts: National Fire Protection Association.

22. LINVILLE, J.L., managing ed., et. al., 1995. *SFPE Handbook of fire protection engineering*. 2-nd ed. Quincy, Massachusetts: National Fire Protection Association.

23. VAN NAO, T., ed., 1982. *Forest fire prevention and control*. The Hague: Martinus Nijhoff / Dr. W. Junk Publishers.

24. QUINTIERE, J.G., 1991. *Principles of fire behavior*. 1st ed. (s.l.): Delmar Learning.

25. FORD, R.T., 1995, *Investigation of wildfires*. Rev. ed. Sunriver, OR: R.T. Ford.

26. BADEN, B., 1994. *Planning for water supply and distribution in the wildland/urban interface: Operation Water*. Boise, Idaho: Boise Interagency Fire Center.

27. CHANDLER, C. et al., 1983. *Fire in forestry.* New York: Wiley.

28. GLASKY, D., 2000. *Complete story of Russian fire engines 1700 to 2000*. Moscow: MosPress.

29. IFSTA, 2003. Wildland fire fighting for structural firefighters. 4th ed. (s.l.): IFSTA.

30. ARNO, S.F., ALLISON-BUNNELL, S., 2002. *Flames in Our Forest.* (s.l.): Island Press

31. CHOCHEV, V., 2003. *Operational tactic for fire suppression*. 1st ed. Sofia: Ogneborets.

32. MISSBACH, K., 1989. *Waldbrand (Forest fires).* 1st ed. Berlin: Deutscher Landswirtschaftsverlag.

33. ALEXANDROV, B. and VRACHEV, I., 1966. *Forest fires.* 1st ed. Sofia: Zemizdat.

b. <u>Articles:</u>

1. BELL, A., 1987. Water bombing of fires: no magic solution. *Ecos 50:* 19-23.

2. CATCHPOLE, E.A., ALEXANDER. M.E., and GILL, A.M., 1992. Elliptical-fire perimeter and area-intensity distributions. *Canadian Journal of Forest Research 22 (7):* 968-972.

3. CHENEY, N.P., 1985. New approaches to fire danger and fire behaviour. Pages 12.1-12.9 *in* Proceedings of Fire Weather Services Conference, 13-14 May 1985, Adelaide, South Australia. Department of Science, Bureau of Meteorology, Melbourne, Victoria.

4. DAWSON, M.P. 1991. Fire bans and public perception of fire danger. Pages 33-41 *in* Cheney. N.P.; Gill. A.M. (Ed.) Proceedings. Conference on Bushfire Modelling and Fire Danger Rating Systems, 11-12 July 1988, Canberra, Australian Capital Territory. CSIRO Division of Forestry, Yarralumla, Australian Capital Territory.

5. FORESTRY CANADA FIRE DANGER GROUP, 1992. Development and structure of the Canadian Forest Fire Behavior Prediction System. *Forestry Canada, Science and Sustainable Development Directorate, Ottawa, Ontario. Information Report ST-X-3.* 63 pages.

6. GEORGE, C.W., and JOHNSON, G.M., 1990. Developing air tanker performance guidelines. *USDA Forest Sen'ice. Infermounfain Research Station, Ogden, Utah, General Technical Report INT-26S.* 96 pages.

7. HIRSCH, K.G., 1991. Development of an initial attack preparedness system for Manitoba. Pages 81 -89 *in* Andrews. PL.: Potts, D.F. (Ed.) Proceedings of the 1l-th Conference on Fire and Forest Meteorology, 16-19 April, Missoula, Montana. *Society of American Foresters, Bethesda, Maryland, SAF Publication 91-04.*

8. MCALPINE, R.S., and WAKIMOTO, R.H., 1991. The acceleration of fire from point source to equilibrium spread. *Forest Science 37(5):* 1314-1337.

9. PERRY, D.G., 1990. "Wildland Firefighting: Fire Behaviour, Tactics, and Command". Second edition. Fire Publications Inc., Bellflower, California. 412 pages.

10. WIITALA, M.R., 1992. "IASELECT: Initial Attack Resource Selector User's Manual". USDA Forest Service, Pacific Northwest Region, Aviation and Fire Management, Portland, Oregon. 31 pages + appendix.

11. KALDONIS, A., 1991. Prevenir, limiter et stopper les incendies de foret. *Revue Generale de Scurite*, 106: 61-64.

12. Interagency Standards for Fire and Aviation Operations. Available at http://www.fire.blm.gov/Standards/redbook.htm.

c. ***Journals:***

1. American Fire Journal
2. Combustion and Flame
3. Combustion Science and Technology
4. Combustion Theory and Modelling
5. Fire (UK)
6. Fire and Flammability Bulletin
7. Fire and Materials
8. Fire and Rescue
9. Fire Australia
10. Fire Chief
11. Fire Engineering (targeted at the fire services, not FPEs)
12. Fire Findings (for fire investigators)
13. Fire International
14. Fire Management Today (US Forest Service)
15. Fire Prevention & Fire Engineers Journal (now merged into one)
16. Fire Protection Contractor
17. Fire Protection Engineering (SFPE)
18. Fire Rescue Magazine
19. Fire Research News (UK govt.)
20. Fire Safety Engineering
21. Fire Safety Journal
22. Fire Technology
23. Firehouse Magazine
24. Forensic Science Communications
25. FS-World
26. Industrial Fire Journal

27. Industrial Fire World
28. International Fire Protection
29. International Journal on Engineering Performance-Based Fire Codes
30. International Journal of Wildland Fire
31. Journal of Applied Fire Science
32. Journal of Electrostatics
33. Journal of Fire Protection Engineering (SFPE)
34. Journal of Fire Sciences
35. Journal of Forensic Sciences
36. Journal of Hazardous Materials
37. Journal of Loss Prevention in the Process Industries
38. Journal of Pyrotechnics
39. National Fire & Rescue
40. NEC Digest (NFPA)
41. NFPA Journal
42. NFPA News
43. Process Safety Progress
44. Progress in Energy & Combustion Science
45. Wildland firefighter
46. Wildfire Magazine
47. Wildfire news & notes
48. International Forest fire news

d. ***WEB sites of fire fighting Internet Sources: Organisations, Government Agencies, Universities, Fire Departments***

1. http://www.nfpa.org
2. http://www.interfire.org
3. http://www.desastres.org
4. http://www.fs.fed.us
5. http://www.feta.org.uk
6. http://www.usfa.fema.gov
7. www.fire.blm.gov
8. http://www.firemaster.co.nz
9. http://www.aeronautics.ru
10. http://www.kamov.ru

11. http://www.fireandsafety.eku.edu
12. http://www.nafi921.com
13. http://investigationsinstitute.com
14. http://www.firehouse.com
15. http://www.americanfireonline.com
16. http://www.airtanker.com
17. http://www.tupelofire.com
18. http://www.sonnet.com/usr/wildfire
19. http://www.airspray.com
20. http://fe.pennnet.com
21. http://fdic04.events.pennnet.com/
22. http://airtractor.com/models
23. http://www.helispot.com
24. http://www.aeronautique.bombardier.com
25. http://www.efiretrucks.net
26. http://www.evotexas.com
27. http://www.tristarbodies.com
28. http://www.newlex-fire.com
29. http://www.hillbillyfire.com
30. http://www.conair.ca
31. http://www.martinmars.com
32. http://www.firehogs.com
33. http://www.ifex-3000.com
34. http://www.ad-fab.com
35. http://www.fpaa.com.au
36. http://www.oxarc.com
37. http://www.kompass.com
38. http://www.geocaching.com
39. http://www.marketresearch.com
40. http://highdesertfire.com
41. http://www.bai.it
42. http://armor-pdi.com
43. http://www.fire.uni-freiburg.de/iffn/country/rus
44. http://www.engj.ulst.ac.uk
45. http://www.brand.lth.se

46. http://www.senecac.on.ca/fire
47. http://www.enfp.umd.edu/
48. http://www.newhaven.edu/courses/FireScience
49. http://www.wpi.edu/Academics/Depts/Fire
50. http://www.fireservicecollege.ac.uk
51. http://mecheng1.uwaterloo.ca/~eweckman/fire
52. http://cee.carleton.ca/Programs/firesafety.html
53. http://www.fireandsafety.eku.edu/
54. http://www.fri.go.jp/indexe.html
55. http://www.vniipo.ru/

e. WEB sites Fire Investigators

1. John A. Kennedy & Associates, Inc. - http://www.kennedy-fire.com
2. Kodiak Fire and Safety - http://www.kodiakconsulting.com
3. FireFacts - http://www.firefacts.com
4. Federated Investigation Service - http://www.fisinv.com
5. Blaze Fire - http://home.centurytel.net/blazefire
6. Barnett Forensic Services, Inc. - http://www.barnettforensic.com
7. Corporate Investigative Services - http://www.arson-codes.com
8. Wolf Technical Services - http://www.wolftechnical.com/index.html
9. Eagle Watch Investigations - http://firms.findlaw.com/eaglewatch
10. Phoenix Fire Investigations - http://www.phoenix-investigations.com
11. Fire Technology Consultants, LLC - http://www.firetechcon.com

f. WEB sites of manufacturers of fire fighting equipment:

1. American LaFrance
   Manufactures a full line of pumpers, tankers, aerials, rescues, ambulances, as well as selling used apparatus and medical supplies. Available at:
   http://www.americanlafrance.com
2. 4Guys Fire Apparatus
   Offers a full line of stainless steel fire pumpers, square and elliptical tankers and walk-in and non-walk-in rescue bodies. Available at:
   http://www.4guysfire.com
3. ABC Fire Protection
   Portable fire extinguishers. Available at:
   http://www.abcfireprotection.co.uk
4. Adams Fire Protection
   Offers emergency and safety equipment, specializing in respiratory protection. Available at:
   http://www.adamsfire.com/

5. Adirondack Fire Equipment
   Vehicle dealer for fire fighting, rescue and safety equipment and apparatus. Available at:
   http://www.adirondackfire.com

6. Advanced Fabrications
   Fabricators of user friendly fire apparatus and custom crafted fire control solutions. Specializes in wild land and urban interface apparatus, and stainless steel units. Available at:
   http://www.ad-fab.com

7. Aerofire Equipment Supplies Emergency Apparatus
   Supplies commercial and custom fire trucks. Available at:
   http://www.aerofiretrucks.com

8. Air One Equipment, Inc.
   Carries a wide range of fire and emergency breathing equipment. Available at:
   http://www.aoe.net/index.html

9. Air-Kwik
   Features an air powered fire fighting system designed for quick response fire patrol vehicles, ideal for class a and b foam. Available at:
   http://air-kwik.com

10. Ajinkya Fire Protection
    Fire fighting equipment. Available at:
    http://www.ajinkyafire.com/

11. Akron Brass Company
    Nozzles, turrets and foam equipment for fire fighting. Available at:
    http://www.akronbrass.com/

12. Allied Fire and Safety
    Provides a broad range of fire protection services and products. Available at:
    http://www.alliedfiresafety.com

13. Allstar Fire Equipment Inc.
    Municipal and industrial fire and safety equipment. Products include hose, breathing apparatus, gas detection, clothing and helmets. Available at:
    http://www.allstarfire.com/

14. American Fire Hydrant Service and Repair Co.
    Features fire hydrant repair, rebuilding, and maintenance programs. Available at:
    http://www.firehydrantrepair.20m.com/

15. American LaFrance Used Apparatus
    Buying and selling late model used fire apparatus and equipment. Available at:
    http://www.efiretrucks.net

16. An Hsin Trading Co., Ltd.
    Produces fire fighting equipment, cctv system and personal protective emergency lights. Available at:
    http://www.anhsin.ttnet.net/

17. Associated Fire Protection
    Designs, engineers, installs and maintains fire protection and safety products. Available at:
    http://www.afpfire.com

18. Augustus Fire Tool
Manufactures a penetrating nozzle for extinguishing motor vehicle fires and compartmentalized fires, as well as related accessories, mounting devices, and packages. Site provides prices, testimonials, and video footage. Available at: http://www.piercingnozzle.com/
19. Barricade International
Manufacturer of water-soluble gel to protect buildings at risk from wildfire. Technical specifications available. Available at: http://www.barricadegel.com/
20. Bay State Fire Protection
Sales and installation of fire protection and detection equipment. They provide spec writing, high sensitivity detection, marine systems, spray booths, communication rooms, chemical storage areas, restaurants, industrial equipment, off road vehicles, clean rooms, record storage, and intelligent systems. Available at: http://www.baystatefire.com
21. Bjornax AB
Provides smoke generating products for ventilation control, control of gas installations, fire training. Based in Sweden. Available at: http://www.bjornax.se/
22. Boca Security and Fire Alarms
For all your home and business fire alarm and security needs. Specializing in marine fire and security, and extinguisher inspections. Available at: http://www.bocafire.com
23. Bracketts Firetruck Sales and Service
Fire apparatus sale and service. Available at: http://brackettsfiretrucksdallasga.com
24. Bullard Thermal Imager
The most durable product on the market, designed to be a practical, reliable tool meeting the needs of firefighters day after day, year after year. Available at: http://www.thermalimager.com
25. BuyFireSupplies.com
Chief Supply distributes rescue, safety, gloves, straps, suspenders, hoods, NFPA, barricade, flashlights, clothing, bags, extrication gear and equipment to fire departments, fire fighters, instructors, and chiefs in the United States and the world. Available at: http://www.buyfiresupplies.com/
26. Cairns Advanced Technology
Features a handheld thermal imager for firefighting using microbolometer technology and job-friendly features. CairnsIRIS mounts on a firefighters helmet for hands-free operation. Available at: http://www.cairnsthermalimager.com/
27. Camiva, fire equipment
Design-manufacture and after-sale service of emergency, rescue and fire fighting vehicles. Based in France. Available at: http://www.camiva.com

28. Canon Fire Protection
Fire protection for businesses, suppling alarms, fire extinguishers and training. Available at:
http://www.canonfire.co.uk

29. Cascade Fire Equipment Company
Manufacturing and distributing a full line of forestry, municipal and industrial fire fighting equipment. Available at:
http://www.cascadefire.com

30. CeaseFire
Manufacturer of patented, dual agent automatic fire extinguishing products. Available at:
http://www.ceasefire.com

31. Chemetron Fire Systems
Integrated fire suppression systems using FM-200, Water Mist, and CO2. Available at:
http://www.chemetron.com

32. CMC Rescue
A wide range of equipment for professional fire fighters. Available at:
http://www.cmcrescue.com/

33. Cordova Fire Equipment
Cordova Fire Equipment includes, nozzles, valves, tips and fittings that withstand the roughest kind of fire line abuse and for the serious firefighter. Available at:
http://www.cordovafire.com/

34. Crown Fire Equipment
Suppliers of fire extinguishers-blankets-first aid kits- hose reels-healthcare products. Available at:
http://www.crownfire.co.uk

35. CSI Emergency Apparatus
Manufacturers, installs and refurbishes custom fire truck tanker and pumper emergency apparatus. Available at:
http://www.csiea.com

36. Custom Composites
Manufacturer of polypropylene and fiberglass water tanks for fire apparatus. 50 to 5000 gal. Located in Oklahoma City. Available at:
http://www.customfiberglass.cc

37. David Deane Associates
Provide film unit fire protection services, fire and rescue appliances and fire engines, water carriers and fire safety boats to any european locations. Available at:
http://www.david-deane-associates.com/

38. Elkhart Brass
Nozzels, deck guns and valves. Available at:
http://www.elkhartbrass.com/

39. Emergency One, Inc.
Manufacturer of a wide range of pumpers, aluminum aerials, tankers, rescues,

and wildland units. Available at:
http://www.e-one.com

40. Emergency Technology and Tactics
Specializing in dry hydrants and other rural water delivery systems, fire product design, training seminars, and live fire videos. Available at:
http://www.ettfire.com/

41. Emergency Vehicles of Texas, Inc.
Authorized fire truck dealer of E-One and Saulsbury. Located in North Texas. Available at:
http://www.evotexas.com

42. EP s.r.l.
Offers filling and assembling machines for fire extinguishers. Based in Italy. Available at:
http://www.epsrl.com/

43. Expressfire
Sales and service of fire safety equipment and fire extinguishers. Available at:
http://www.expressfire.co.uk

44. FDC Rescue Products
Supplier of respirators, industrial and fire fighting SCBA, thermal imaging and personal accountability and lighting systems. Available at:
http://www.breathingez.com

45. Fire Brake Company
Offers a wide variety of fire and emergency equipment. Available at:
http://www.firebrakeco.com

46. Fire Equipment Liquidators
Discount fire equipment. Available at:
http://www.dotnet.com/~fel

47. Fire Escape Systems
We market a complete line of portable and permanent fire escape ladders for home, apartment and offices. Available at:
http://www.fireescapesystems.com

48. Fire Facilities Inc.
Manufacturers of Wesco steel training towers featuring 1200 degree(F) Westemp insulated burn rooms. Available at:
http://www.firefacilities.com/

49. Fire Fighters Equipment Co.
Scott Air Paks, Globe and Cairns turn-outs, La Crosse footware, Warrington leather footwear, Fire Grip Gloves, and Federal warning lights. Available at:
http://www.firefightersequipco.com/

50. Fire Proofing Wood with Sodium Silicate
This article presents a way of fire proofing wooden buildings using sodium silicate solution. Available at:
http://www.angelfire.com/nc/isoptera/index.html

51. Fire Rescue Outfitters
Offering practical, field proven, products designed to meet the unique, ever changing needs of today's emergency service agencies. Available at:
http://www.fire-rescueoutfitters.com

52. Fire Retardant Service and Supplies
Distributor of fire retardant products in liquid, penetrants, coatings, additives, and thermal barriers. Available at:
http://www.fireretardantservice.com

53. Fire Trucks Inc.
Sells Fire Equipment and Used Apparatus. Available at:
http://www.firetrucksinc.com

54. Firecom
Manufacturer of headset and intercom systems for fire apparatus and emergency vehicles, and a complete line of hearing protection and communication equipment. Available at:
http://www.firecom.com/

55. Fire-EMS Information Network
An extensive list of fire and fire fighting related links and manufacturers websites. Available at:
http://www.fire-ems.net/productsservices.html

56. Firefighter
Offer portable foam systems, nozzles, foam kits, eductors, foam proportioners, forestry backpack pumps, accessories. Worldwide. Available at:
http://www.scottyfire.com/

57. FireGuard
Vendor of fire and safety related products, including first aid kits, fire extinguishers, flashlights and emergency lighting, fire suppression systems, professional equipment, and related supplies. Available at:
http://www.fireguardusa.com/

58. Firehog innovations
Offers Firefighters and EMS personnel an opportunity to promote and advertise their inventions, products or services. Available at:
http://www.firehog.com

59. FireNet
Website for the British Fire Service. Includes marine and aviation fire fighting. Available at:
http://www.fire.org.uk/

60. Fireshield Sdn Bhd
manufacturer of fire fighting equipment, safety and protection equipment. Specialized in fire hose, water tank, extinguisher and fire box. Malaysia. Available at:
http://www.asiapacific.com.my/fireshield/index.html

61. FireSwap
For the firefighter, volunteer or fire buff to buy or sell fire related items such as fire department t-shirts, and memorabilia. Available at:
http://www.fireswap.com

62. Firetec Apparatus Sales
Used fire apparatus dealer with online catalog of available units. Available at:
http://www.firetec.com

63. FireUSA.com
New and used fire apparatus and equipment broker. Available at: http://www.fireusa.com

64. Firewater Systems, Inc
Manufacture residential fire sprinkler water storage tanks and delivery pumps. Based in Harrisburg, PA. Available at: http://firewatersystems.com/

65. Flame Seal Products
Liquid Fire Retardants, Coatings and Fire Protective Wraps. Available at: http://www.flameseal.com/

66. FPS Fire Protection Limited
Manufacturers and suppliers of portable fire extinguishers in the UK. Available at: http://www.firemarkext.co.uk

67. Good Hope Fire Apparatus
Manufacturer of low-profile, custom tankers as well as new tankers and used tankers, water tenders, water carriers and stainless steel baffled tanks. Available at: http://www.goodhopefire.com

68. Guardian Fire Equipment
Fire fighting equipment. Established 1986. Available at: http://www.guardianfire.com/

69. H.L. Bouton Company
Manufacturing eye protection products for more than fifty years. They offer safety spectacles, goggles, face shields, replacement lenses and lens cleaners. Available at: http://www.hlbouton.com/

70. Haight Fire Equipment Supply
Supplier of fire fighting equipment for fire departments and firefighters and fire protection and industrial safety products for businesses, schools, and homeowners. Available at: http://www.haightfire.com/

71. Hannay Reels
Hannay Reels, maker of hose & cable reels for fire fighting hose. Also makes a wide variety of cable and other reels. Available at: http://www.hannay.com/

72. Hillbilly Fire Apparatus
Hillbilly Fire Apparatus sells used fire trucks, pumpers, tankers, aerials, rescues, fire equipment and fire fighting gear. Available at: http://www.hillbillyfire.com

73. Hoechst Celanese Acetate LLC
Manufacture fire fighting turnout gear, industrial apparel and other apparel for high temperature applications. Includes a listing of suppliers and product literature in pdf format. Available at: http://www.pbigold.com/

74. Holland Equipment, Inc.
Holland Equipment manufactures custom built rescue vehicles equipped for Wildland, Initial Attack, Light Rescue, EMT and Special Services applications. Available at: http://www.hollandrescue.com

75. Impact Systems
Manufacturers of abc fire extinguishers, detection systems, glow signs, as well as automatic extinguishers and fixed fire fighting installations. Based in India. Available at:http://www.indiamart.com/impactsystems

76. Integrated Safety Services of Colorado, LLC
Fire protection services. Available at: http://hometown.aol.com/lesuzuki/index1.html

77. Iron Duck Products
A provider of products to the emergency medical, fire fighting, and law enforcement professional. Available at: http://www.ironduck.com/

78. J L Industries
Manufacturer of fire extinguishers, cabinets and access panels. Available at: http://www.jlindustries.com/

79. Kidde PLC
Industrial fire fighting products include fire trucks, hose reels, sprinkler systems, fire extinguishers, smoke detectors and escape ladders. Available at: http://www.kidde-int.com/

80. L. N. Curtis and Sons
Distributor of fire fighting equipment as well as emergency rescue and safety tools. Available at: http://www.lncurtis.com/

81. LDM Products.
Fire nozzles and hose accessories for the fire fighting industry. Available at: http://www.firenozzles.com

82. Magnasafe International
Offers fire equipment, foam, reels, suppression, extinguishers, emergency equipment, and fire protecting clothing. Available at: http://www.magnasafe-intl.com

83. Magnum Fire and Safety Systems
Manufacturer of fire fighting equipment, foam systems, fire pumps, monitors, and hose equipment. Available at: http://www.magnumfire.com/

84. Mainstream Dry Hydrants.
Supplier and installer of dry fire hydrants for rural fire protection. Includes photos and illustrations and pricing. Available at: http://www.dryhydrants.com/

85. Maltese Fire Equipment Company
Offers a range of accessories to support firefighters. Available at: http://www.maltesefire.com

86. Marconi Applied Technologies
Offer a thermal imaging camera for firefighters. Direct purchasing available from the manufacturers. Includes data sheet, product features and technology information. Available at: http://www.argusdirect.com/

87. Metalfab
Features fire trucks and supplies made in Centreville, New Brunswick, Canada. Available at: http://www.metalfab.nb.ca

88. Metron
Offers a line of diesel and electric fire pump controllers as well as power distribution equipment, and golf course irrigation pumping solutions.

Available at:
http://www.metroninc.com/

89. MIH Manufacturing Inc.
Manufactures a full line of misting products that range from low to high pressure for sports, military, industrial, and fire fighting uses. Available at: http://www.foggu.com/

90. Minimax GmbH
Learn about this argon fire suppression system using a clean agent with zero ozone depletion potential and zero global warming potential for occupied spaces. Available at: http://www.minimaxusa.com/

91. Mogol Makina Sanayi Ltd. Sti.
Manufacturer of fire engines, ambulances and special vehicles for law enforcement. (Turkish and English) Available at:
http://www.mogol.com

92. Municipal Equipment Company
Fire fighting equipment distributor. Available at:
http://www.municipalequipment.cc

93. N & N International
Suppliers of fire sprinklers, fire hoses, valves, Fire Department connections, pipe fittings. Available at: http://nni.8m.com

94. New Lexington Fire Equipment
Offers hand crafted stainless steel or aluminum pumpers, tankers, rescues, as well as aerials. All apparatus is built to customer's specifications. Available at: http://www.newlex-fire.com

95. Nick's Custom Boots
Firefighters footwear and caulks. Available at: http://www.nicksboots.com/

96. Ningbo Yunfeng Fire safety equipment Co.,Ltd
Manufacturer of fire extinguishers and fire fighting fittings and accessories. Available at: http://www.yunfeng-fire.com/

97. Nor Environmental Ltd
Chemical decontamination equipment and training. Available at:
http://www.nbcdefense.net

98. Nordic Systems Inc.
Manufacturer of fire fighting components and skid systems for original equipment manufacturers of fire fighting apparatus. Available at:
http://www.nordicsystems.com/

99. Nu-Swift Ltd
Suppliers of fire extinguishers, servicing and training for business and residential use. Available at:
http://www.nu-swift.com

100. Orion Safety Products
Flares and distress signals. Available at:
http://www.orionsignals.com/

101. Pac Mule
A hands-free truckmens belt that meets the NFPA standard 1983, 1995 edition. Available at:
http://www.pacmule.com/

102. Patol Limited
Manufacturers of linear heat detectors/fire detecting cable. Available at: http://www.patol.co.uk/
103. Pennsylvania Firefighter
Resource site containing links to fire fighting and EMS products, services and general information. Available at: http://www.emergencypreplans.com/
104. Peripheral Support Services Ltd
Fire alarm and control equipment. Available at: http://www.pss-firequest.co.uk
105. Phillips & Smith Limited
Displays a sample range of fire equipment products made by this firm and distributed throughout Australasia, the Middle East, UK, and South Africa. New Zealand based. Available at: http://www.firemaster.co.nz
106. Pierce Manufacturing
Manufactures custom pumpers, tankers, aerials, rescues, and emergency apparatus. Available at: http://www.piercemfg.com
107. Red Rock Fire Suppression Systems
Stand-alone fire suppression. Available at: http://www.redrocksystems.com/
108. Richards Hose Ltd
Manufacturers and suppliers of layflat hoses for fire fighting and industrial purposes. Available at: http://www.richardsfire.co.uk/
109. Safety Technology International Inc.
Markets products throughout the world to prevent false fire alarms and the theft and vandalism of smoke detectors and fire extinguishers. Available at: http://www.sti-usa.com/
110. Salmen Tech Company, Inc.
Provide intrinsic safety equipment, purge systems, actuators, gauges, and fire and gas detection tools. Available at: http://salmen.freeservers.com
111. Securitex Incorporated
Specialists in NFPA approved firefighter protective clothing & turnout gear, using Nomex, Kevlar and PBI fire fighting fabrics. Available at: http://www.securitex.com/
112. Simon Fire Equipment
Designs and makes fire and rescue apparatus to specification including pumpers, tankers, rescues, and quick attacks. Available at: http://www.simonfire.com
113. SmartCoat Inc.
Heat sensing alarm for turnouts. The encapsulation of firefighters today makes determining dangerous heat conditions very difficult. This alarm is fitted into your turnouts to warn the FF to the conditions he may not be able to detect. Available at: http://www.smartcoat.com/

114. Southern Fire Service and Sales
Service and manufacturing of fire trucks, fire rescues, and fire tankers. Available at:
http://firerescues.com
115. Spectrum Fire Protection (UK) Ltd
Offering installation and servicing of fire protection equipment (UK). Available at:
http://www.spectrumfire.co.uk/
116. Steel Recon Industries
Suppliers of equipment for fire protection and industrial safety products. Available at:
http://www.sri-msia.com/
117. Sutphen East Corporation
Custom fire fighting apparatus and refurbishing. Available at:
http://www.sutpheneast.com
118. Swede Survival Systems Incorporated
Flashover recognition and prevention training in a controlled live fire environment. Available at: http://www.swedesurvival.com
119. Talion Corp
Featuring all kinds of helmets, emergency equipment including body cooling products for emergency workers and their K9 friends. Available at:
http://www.talioncorp.com
120. The Video Unit
Offers video production and editing services for the fire and emergency services industry. Available at:
http://www.thevideounit.com/
121. TRI-STAR Emergency Vehicle Core Bodies
Fabricates custom emergency equipment and commercial truck core bodies. Specializes in private label, second stage intermediate body manufacturing. Available at: http://www.tristarbodies.com
122. Tupelo Fire Equipment
Manufacture fire tankers, pumpers, rescue units, aerial ladder trucks and associated equipment. Available at:
http://www.tupelofire.com
123. TurboDraft Fire Eductor
Features Schutte and Koerting's fire eductor that allows fire companies to tap into water supplies like ponds, streams, and swimming pools. Available at:
http://www.Turbodraft.net
124. Turning Star, Inc.
Providing on-site flame proofing treatment, fire retardant testing and certification. Available at:
http://www.turningstar.com
125. US Fire & Equipment
Distributors of municipal and wildland equipment and trucks. Buys and sells surplus fire equipment. Available at:
http://www.usfireequipment.com

126. W.S. Darley and Company
Provides fire fighting equipment from shoes to entire Fire Trucks. Available at:
http://www.edarley.com/

127. Wheelock, Inc.
Wheelock manufactures high quality Fire Signaling Appliances,Voice Evacuation Systems,Telephone Signaling Devices, Telephone Paging Equipment and Industrial Signaling Products. Available at:
http://www.wheelockinc.com

128. Yongtai Fire-fighting Equipment Co.
Produces fire-fighting equipment,contain fire hose,fire hose used for fire vehicle, can supply coupling and branchpipes at various country standards. Available at:
http://www.chinafire.com

129. http://www.rosenbauer.com

130. http://www.tht.cz

131. http://www.ericksonaircrane.com

Encyclopaedias

1. http://www.encyclopedia.com
2. www.encarta.msn.com
3. www.britannica.com
4. encyclopedia.thefreedictionary.com
5. www.asinah.net/en/wikipedia/f/fi/fire.html
6. www.encyclopedia4u.com/f/fire.html
7. www.encyclopedia.ekist.de

Contacts & Correspondence

1. **Cailen Hegman**
MTDC Publications
5785 US Highway 10 West
Missoula, MT 59808
Phone:406-329-3978
Email: cahegman@fs.fed.us

2. **Bert Lindler**
Supervisory Technical Editor
Missoula Technology and Development Center
5785 Highway 10 W
Missoula, MT 59808
Phone: (406) 329-3930
Fax: (406) 329-3719
Email: blindler@fs.fed.us

3. **Leslie Anderson**
   Missoula Technology and Development Center
   Office: 406-329-1043
   Email: landerson@fs.fed.us

4. **Colin Legg**
   Institute of Ecology and Resource Management
   The University of Edinburgh
   Darwin Building, King's Buildings
   Mayfield Road
   Edinburgh, EH9 3JU
   Scotland
   Email: colin.legg@ed.ac.uk

5. **Paul Steensland**
   Senior Special Agent
   Office: (530) 257-2151
   Direct Line: (530) 252-6640
   Cell: (530) 227-3231
   Email: psteensland@fs.fed.us

6. **Lynsey Houston**
   Supervisory Technical Editor
   University of Ulster (FireSERT), UK - Fire Safety Engineering Research & Technology Centre
   Email: online@ulst.ac.uk

7. **Scott C. Idleman**
   Information Director, NFCA
   Email: idleman@fire-command.org

8. **Sheri Ascherfeld**
   External Affairs, National Office of Fire and Aviation Bureau of Land Management
   National Interagency Fire Center
   (208) 387-5144
   Email: Sheri_Ascherfeld@nifc.blm.gov

9. **Ron Hopkins**
   Ashland, Inc Fire and Safety Laboratory,
   Room 104
   859-622-1053 Voice
   859-622-1530 Fax
   E-mail: lpshopkins@acs.eku.edu

10. **David O. Howell**
    Public Affairs Specialist
    BLM Upper Snake River District
    tel: (208) 524-7559

fax: (208) 524-7505
E-mail: David_Howell@blm.gov

11. **Simona Borza**
Edwards Manufacturing Inc.
2441 SE Stubb St
Milwaukie, OR, USA 97222 Telephone: (503) 659-4198; Fax: (503) 654-3110
E-mail: sales@edwardsmfg.com

12. **Chris Bielecki**
Master of Forestry Candidate
Oregon State University
Department of Forest Engineering
215 Peavy Hall
Corvallis, OR 97331
Office: 541-737-4952
Fax: 541-737-4316
Email: chris.bielecki@oregonstate.edu
Web: http://www.cof.orst.edu/cof/fe/students/bielecki.htm

13. **Robert J. Krempasky**
Director of Sales & Marketing, R&D
Western Fire Inc.
177 West Cottonwood Lane
Suite 11
Casa Grande, Az 85222
Office: 520-421-7008
Fax: 520-421-9047
Email: bobk@wfiaz.com
Web Site: www.wfiaz.com

14. **Ed Herlik**
Technical Manager
AeroTech Ltd.
Email: Firehogs@aol.com

15. **Bill Greene**
Fire Marshal
City of Davis, California
Email: FireWeb@ci.davis.ca.us

16. **Jo Crawford**
Program Assistant
RWU4401, Fire Behavior Project
Rocky Mountain Research Station
Fire Sciences Lab
Phone: 406-329-4820
Fax: 406-329-4825
Mailing address
P.O. Box 8089

Missoula, MT 59807
Email: jmcrawford@fs.fed.us

17. Canon Fire Protection providing sales and service of all fire equipment to businesses and brigades
Email: cfp@canonfire.co.uk (General Enquiries)

18. University of Central Lancashire, UK – Department of Built Environment Fire Course programmes
Email: cenquiries@uclan.ac.uk (General Enquiries)

19. **Naomi Davidson**
Webmaster
CT Department of Environmental Protection
E-mail: dep.webmaster@po.state.ct.us

CHAPTER3: PATENT SEARCH FOR SPECIAL FIRE-FIGHTING METHODS AND SYSTEMS

Research that has been done included the determination of the aims and purpose of the patent search; Performing of search for finding the patent office's Web Sites that were of interest; Setting the criteria for results selection and structuring; the patent search and selection; and the performance of the result classification.
The aims of the performed Patent Search were for:

1) establishing the absence of a patent that could eventually hinder legalization of a future development in the above area of research;
2) acquiring information on the level of innovative thinking in the area of forest fire fighting methods and systems;
3) discovering out of the ordinary principles that are applicable to the specific area of research;
4) identifying disadvantages of the currently available systems and methods (disadvantages noticed in developments in a stage of improvement are usually indicated in patented improvements).

3.1 Patent databases

An overview of patents registered in the following databases has been carried out in:

- Europe's Network of patent databases - esp@cenet (http://gb.espacenet.com/);
- The UK Patent Office (www.patent.gov.uk);
- The United States Patent Office - USPTO Patent Full-Text and Image Database (http://patft.uspto.gov);
- Australia's Published Patent Data Searching (http://apa.hpa.com.au);
- The Canadian Intellectual Property Office (http://patents1.ic.gc.ca);
- The Hellenic Industrial Property Organisation (http://www.obi.gr).

Why did we choose these databases?
The basic search has been carried out in Europe's Network of patent databases since most of the patents from the other countries are also registered there (to provide intellectual property rights for the territory of Europe as well). The aim of performing a basic study of patents that are valid for the territory of Europe, the USA and Australia has been decided in order to cover all these areas, under the term "*Mediterranean ecosystem*".

Approach

- ***Selection of the results***

The key words "fire fighting system" and "forest fire" were used. The results of the search were an enormous number of patents. Each individual result was treated as follows:

- Reading and short analysis of Patent's *Abstract*. This particular analysis was made to screen out the patents that are outside the scope of interest of the specific development task. These were excluded from further study activities.

- The full text was also viewed for the rest of the patents (Patent's original) along with attached drawings. Here again a screening was performed to exclude those patents that are not considered of being of interest.
- The rest of the results were grouped according to some similar characteristics.

Results

From 832 patents, arranged in order of appearance, 52 were selected and classified in 4 groups of inventions in the Table below.

Patent Number	Theme	Group
GROUP 1 Methods and systems ***involving delivery*** of the extinguishing agent by means of ***shooting*** it using an initial impulse or thrust.		
US2003226554	Fire retardant guidance systems with fire extinguishing ammunition	1
WO03004102	Fire fighting method and apparatus	1
JP9075472	Fire fighting device, fire engine and fire fighting system	1
FR2603492	Equipment and batteries of self-propelled missiles for fire prevention and fighting. Anti-fire rockets and launchers	1
US5507350	Fire extinguishing with dry ice	1
RU2193906	Fire-extinguishing method and rocket-type fire-extinguishers for effectuating method	1
RU2146545	Method of fighting of forest, steppe and other fires and gear for its implementation	1
GROUP 2 Methods and systems involving delivery of the extinguishing agent by means of gravity where the agent is ***exploded or sprayed*** over the fire from tanks, missiles, containers, etc. using aviation carriers, such as helicopters and air planes.		
US4344489	Aerial forest fire extinguishing device	2
EP0320554	Air borne device for fighting forest fires.	2
US2349980	Forest fire extinguisher	2
GR80756	Manufacture of bombs for extinguishing forest fire	2
RU2177814	System for explosive fire extinguishing of vast forest fires for aircraft	2
RU2171125	Blasting device for fighting against forest fire	2
RU2158621	Method for suppressing of forest top fires on vast areas	2
US2001025712	Water loons	2
RU2147901	Forest fire suppression method	2
RU2146544	Method fighting crown and ground forest fires and gear for its implementation	2
US5894891	Method and device for extinguishing fires	2
FR2603193	Explosive container for fire-fighting - comprises light metal or plastics tank with height-dependent detonator to release liquefied extinguish	2
WO9706858	Process and device for fighting fires from the air	2
CN1432787	Air-dropped pressure-storing automatic forest fire extinguishing bomb	2
RU2078600	Fire-fighting device for fighting of forest and steppe fires	2

GROUP 3 Jet-systems for **continuous** spraying of the extinguishing agent over the fire.

US6581878	Airborne fire fighting system	3
US5590717	Fire extinguishing capsule	3
US2002088898	Airborne fire fighting system	3
GR98100374	Fire-fighting mechanism adapted to land vehicles	3
US5699862	Foam generating device for fire-fighting helicopter	3
FR2610894	Method and appliance for projecting a liquid product or the like, or a solid object, from an aircraft	3
FR2538341	Method of air transport and airframe for implementing this method	3
CN1081116	Air borne fire-extinguisher	3
US4616711	System and method of controlling and preventing the spread of forest fires	3
ES2081762	Air/fire fire-extinguishing system	3
ES8608903	Fire fighting system	3
EP1053935	Method for extinguishing fires from an aircraft and related device	3
FR2691366	Mobile vehicle for combating forest fires.	3, 4
FR2672223	Device intended for fire fighting and for the prevention of fires and pollution	3, 4
US6125942	Aircraft-based fire-fighting bucket	3, 4.1
IT1241915	Sprinkler cannon for extinguishing forest fires	3,4.1

GROUP 4 Earth-based extinguishing system**.**

US3724554	Fire fighting system	4
FR2568779	Method for fighting forest fires	4
FR2652268	Armoured (shielded) vehicle for close-up intervention in forest fires in all terrains	4
US3635290	Apparatus for fighting forest fires	4
SU1834667	Method of fighting forest fire	4
SU1697855	Method for preventing low forest fire from turning to upper forest fire	4
SU1657199	Method for forest fire fighting	4
SU1799608	Equipment for quenching fringe of forest fire	4
WO0230515	Fire-fighting system	4
US5836398	Vehicle mounted fire fighting system	4
US2003066659	Fire-fighting system having improved flow	4

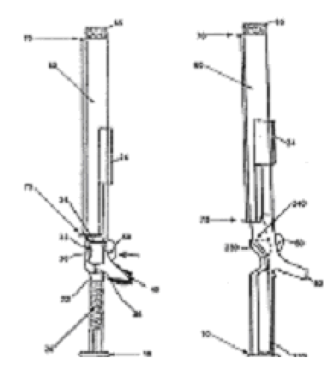
GROUP 4.1 *Supplementary* systems, methods and equipment.

GB1135929	High expansion foam generator	4.1
RU2184584	Pulsed unit	4.1
FR2627391	Forest fire-fighting method – uses water-filled tanks delivered by helicopter from strategically located-storage points	4.1

3.2 Patent Analysis

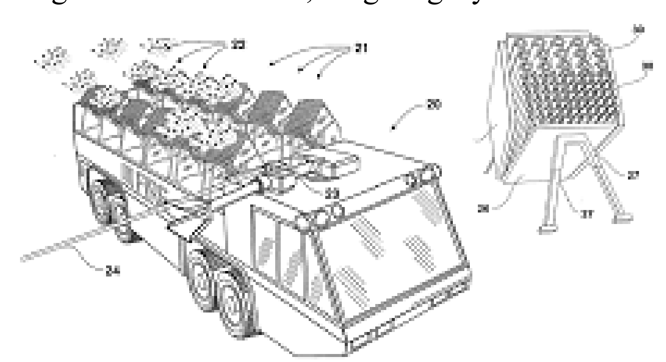
Methods and systems involving delivery of the extinguishing agent.

The general in the patents from GROUP 1 is the using of methods and systems involving delivery of the extinguishing agent by means of shooting it using an initial impulse or thrust. It's the most interesting group.



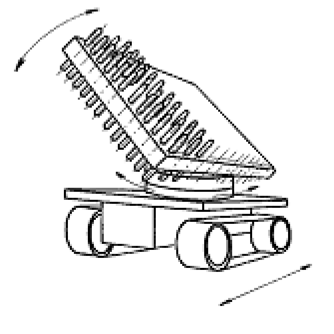
US2003226554 Fire retardant guidance systems with fire extinguishing ammunition: The gun (rifle) **propels** ammunition on a **water-based foam**, which **explodes** upon impact onto a target. The ammunitions of this system have **not direct contact** with the chemicals. The fight is from approximately **10m distance**. 2 rifle variants: 1). with spring, hydraulics and launch mechanics; 2). with compressed gas cylinder. Using **fluid mechanics** for ammunition propulsion exclusively. The chemicals are environmental friendly. For class A fires.

WO03004102 Fire fighting method and apparatus. The **most interesting** patent. It has large area of volume, targeting system and an **ordnance** with one or many barrel assembly. The **projectiles** are many, axially disposed within the barrel. The projectiles content different kinds of fire retardant and discrete **propellant charges**. Ignition of the propellant may be achieved **electrically** or may utilise conventional firing pin type methods. The explosion occurs over the target area by **radio signal** or by ground contact.



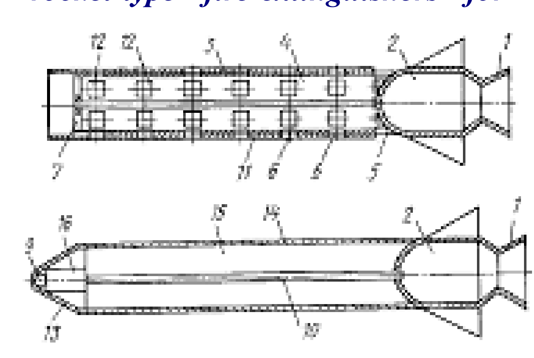
JP9075472 Fire fighting device, fire engine and fire fighting system. The unit has barrel assembly that shoots **ball projectiles** with fire suppressants to the flames. Preliminary added targeting system had got needed data – direction, distance. The fire extinguishing balls are properly thrown on a fire and **self-blast**. For **10-15m distance** fighting. Advantages: high accuracy of shooting, smaller material looses. For class A fires.

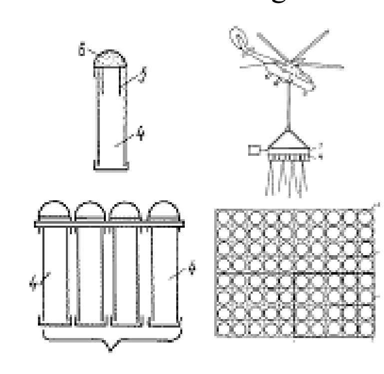
FR2603492 Equipment and batteries of self-propelled missiles for fire prevention and fighting. Anti-fire rockets and launchers. That is highly mobile anti-fire battery with an automatic device to obtain a variable inclination of the carrier rockets or missiles– grenades or other types do small explosive and fire fighting projectiles. The ballistic carrier rockets are fitted with powder rocket motor. The mobile launch battery (ordnance) may rotate on a circular guide, depending on direction of firing. It has range of 200 to 1500m or more. Advantages: It assures very high concentration of anti-fire impacts- rockets exploding on the ground, using short time and it has small sizes. That may surround the fire spots by trenches or/and be airborne.



US5507350 Fire extinguishing with dry ice. Method for remote and early response of **solid carbon dioxide** in **capsules** by standard **artillery guns** to cool the fire. **Projectiles** of encapsulated solid carbon dioxide are **launched** as projectiles from standard artillery guns. They pass one-third of the way into the fire from the leeward side- carbon dioxide migrate through the fire. For class A fires.

RU2193906 Fire-extinguishing method and rocket-type fire-extinguishers for effectuating method. The method uses airborne **rockets-type** fire extinguishers for transportation of fire-suppressants to the fire zone. Several devices in the rockets body as nozzles, air intake device, pyrotechnic cartridge, control signal receiver, cut of Bickford fuse, container and casing movably mounted on container, obturator detachably positioned on casing make possible exact time/Delay/and position for fire-suppressant dispersion. Other kind of rockets charged with explosive can extinguish the fires by **air knock wave**.



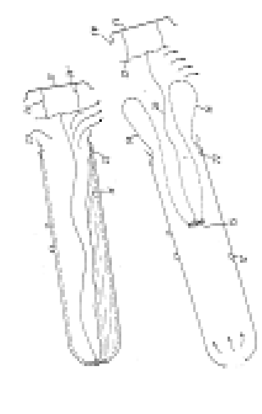


RU2146545 Method of fighting of forest, steppe and other fires and gear for its implementation. Fighting fires with simultaneous salvo of fire-fighting substance from several **fire-hose barrels** from **pulse** platform suspended from helicopter, for instance. Barrels are smooth and have same diameter over entire length. They are fitted with aids suppressing recoil. Invention provides for charging of cartridges with election charges under stationary conditions.

2.2.2 Delivery of the extinguishing agent by means of gravity.

Patents from GROUP 2 refer to methods and systems involving delivery of the extinguishing agent by means of gravity where the agent is exploded or sprayed over the fire using aviation carriers, such as helicopters and air planes.

US4344489 Aerial forest fire extinguishing device. **Projectiles** are filled with an **inert pressured gas** – fire suppressant. The projectile disperses it by plurality of ports into the fire, when the device impacts the ground.



EP0320554 Air borne device for fighting forest fires. A fighter-bomber is carrying an **envelope formed body /bomb/** charged with fire extinguishing product. The airplane launches the body to the fire. The bomb has a **ballistic trajectory**. The rear cover is opening during this travel and suppressant is **dispersing continuously** over the fire region.

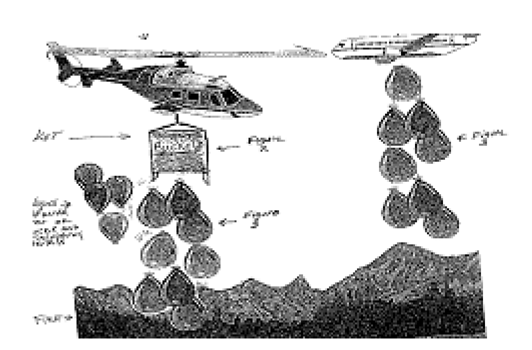
US2349980 Forest fire extinguisher. An airplane-bomb that have within both **extinguishing material and explosive**. When the bomb strikes an obstructing object such as ground, trees crown or bush the explosion hurling a extinguishing chemical onto the area. It **detonates** a **substantial** distance above the ground for more effectively disperse the fire suppressant.

GR80756 Manufacture of bombs for extinguishing forest fire. Technology of bomb preparing. Parameters.

RU2177814 System for explosive fire extinguishing of vast forest fires for aircraft. Air-born fire-extinguishing system consisting of tanks for extinguishing fluid and pumps for making **long stream** to the bigger forest and other fires. The mixing of extinguishing chemical with air **explodes** when comes into contact the fire flames.

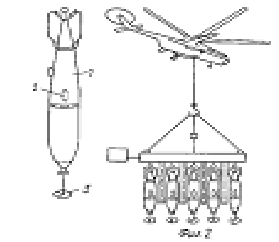
RU2171125 Blasting device for fighting against forest fire. This is blasting air-born device that has several **explosive charges** placed in a package, stabilizing parachute and altitude sensor-detonator. When the package is released from the aircraft it is falling down to the forest fire and the explosion occurs about the tree crowns altitude. The explosion extinguishes the flames.

RU2158621 Method for suppressing of forest top fires on vast areas. The method involves forming single bomb packs containing vessels filled with liquid carbon dioxide and detonator. The airborne packs are dropping to the top fire boundary from altitude 600-800 m and single pack of bombs explodes at **predetermined altitude**. **Evaporating liquefied gas** moves along ground surface and extinguishing the fire. The method increases efficiency for suppressing fires on **vast** areas.



US2001025712 Water loons. Water sealed in **plastic balloons** would be dropped on the flames directly above by airborne buckets. Because missing of evaporation the full volume of water reaches to high temperature fire zone and suppressing more efficiency the flames.

RU2147901 Forest fire suppression method. Air-born **ice-liquid-nitrogen bombs** are thrown over the fire. They will be destroyed when meets the flames and ground surface. Both the ice water and Nitrogen–gas strong reduce the temperature and extinguish quickly the fire.



RU2146544 Method fighting crown and ground forest fires and gear for its implementation. An air-born polyethylene-bags bombs full with extinguishing material and explosive /600:1/ are dropped over the fires in difficult of access and remote areas. They deliver fire-fighting substance to center the fire. The bombs explode by impact of ground, or bushes or tree crown.

US5894891 Method and device for extinguishing fires. The containers such a **plastic bags** or hoses have both the extinguishing agent and **explosive** in or on the containers. For forest fire the containers are air-born and may be dropped such a bombs or in lines over the fire. By the explosion the extinguishing dust or water, or another material is dispersed such **as mist** at the region. The explosion wave is also used to extinguish the fire.

FR2603193 Explosive container for fire fighting - comprises light metal or plastics tank with height-dependent detonator to release liquefied extinguish. An air-born containers made by light metal or plastics full within both extinguishing liquefied carbon dioxide or Nitrogen and explosive. They are dropped over the fire front at predetermined altitude to assure optimum distribution of the extinguishing gas.

WO9706858 Process and device for fighting fires from the air. This is an air-born **"water" bomb** with stabilizing parachute in plastic bag and **explosive charge** within. The explosion occurs at predetermined altitude over the fire commanded by **fuse, timer or radio impulse**. The water mist cloud is extinguishing the flames and the fire.

CN1432787 Air-dropped pressure-storing automatic forest fire extinguishing bomb. An air-born bomb with extinguishing material and stabilizing parachute, that may disperse it from orifices /openings/ automatic during the falling down to the fire.

RU2078600 Fire-fighting device for fighting of forest and steppe fires. The device is air-born by helicopter frame that caring many plastic containers with both extinguishing material and explosives within. The extinguishing material is **dispersing** over the fire by the **explosions**.

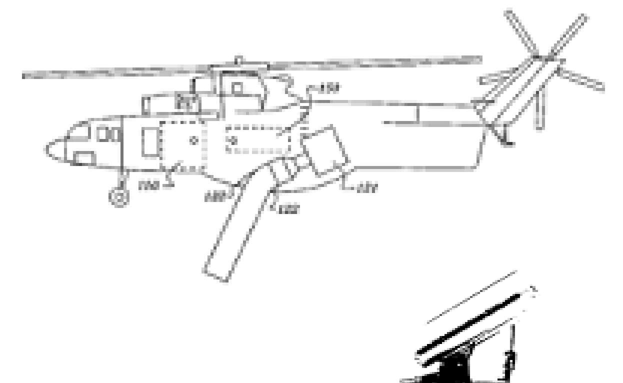
2.2.3 Methods and Jet-systems for continuous spraying.

Patents from GROUP 3 refer to Methods and Jet-systems for continuous spraying of the extinguishing agent over the fire.

US6581878 Airborne fire fighting system. System and method for pressurizing and dispersing fire retardant from an aircraft.

US5590717 Fire extinguishing capsule. The fire-extinguishing capsule comprises two double-walled hemi shapes, which are sealed together by an equatorial belt seal, which may be raptured in order to disperse the extinguishant in the capsule.

US2002088898 Airborne fire fighting system. Airborne fire fighting system comprising a helicopter and a pair of tiltable **jet engines** where the exhaust can be directed at the fire under the control of the pilot or other fire fighting crew. AFFS comprises a **rotor-powered craft**, fitted internally with a jet engine. The jet exhausts impacts the ground in front of an advancing firewall and bounces through the firewall, extinguishing that segment of the fire. In this patent are many interesting cases of fire attacks.



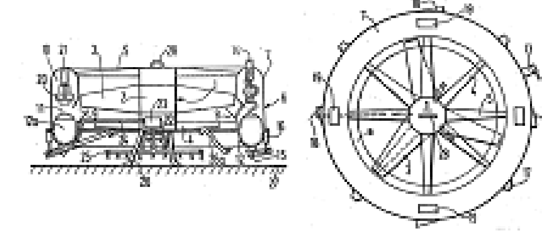
GR98100374 Fire-fighting mechanism adapted to land vehicles. A directed **air launcher** having the possibility of producing and

launching at high-speed oxygen-free atmospherical air at the required range and volume. Inside the air-propulsing element there is a special boiler system which is designed to remove the oxygen from air.

US5699862 Foam generating device for fire-fighting helicopter. Foam generating device and 1). means for mixing water with a chemical emulsion product or emulsifier under pressure, and 2). air-pressurized means to create expanding foam from the water-emulsifier mixture, and for projecting said foam on the site on fire.

FR2610894 Method and appliance for projecting a liquid product or the like, or a solid object, from an aircraft. The appliance comprises at least one receptacle advantageously in the shape of a cylindrical tube inclined rearwards, this receptacle being linked, at its upper part, to the **pressurisation device** already fitted to the aircraft.

FR2538341 Method of air transport and airframe for implementing this method. Air frame with rotary wings comprising a central unit equipped with at least one engine and a vertical-axis propeller.



CN1081116 Air borne fire extinguisher. The air-dropped fire extinguisher consists of an eared casing full of fire extinguishing agent, a flame-detecting starter at the head of casing, a power source in the middle of casing and connected to the starter, and a stabilizer at the tail of casing.

US4616711 System and method of controlling and preventing the spread of forest fires. To form the foam strip, the invention discloses the method of dropping **foam-containing containers** from an aircraft in a selected pattern along the strip area designated. The foam containers are provided with **valves** that open approximately on impact or at a selected time thereafter to cause the release of the foam.

ES2081762 Air/fire fire-extinguishing system. This system employs an element, for generating air at great pressure, equipped with a flexible high-pressure hose which, duly oriented, projects a flow of air onto the fire at a pressure of from 10 to 50 kg per cm^2. It is being possible to mix the air with an abrasive such as silica and also with water, in order to produce a wet-air/abrasive mixture.

ES8608903 Fire fighting system. A description concerns an improvement made to fire fighting systems, which have pump discharges an aqueous solution of foam-forming concentrate. The method is spraying a stream of liquid of small volume of fluid. The fire fighting composition is formed from a concentrate with one or more non-ionic surface-active agents. The fire fighting solution is thus sprayed onto fires in order to constitute an effective measure for combating fires.

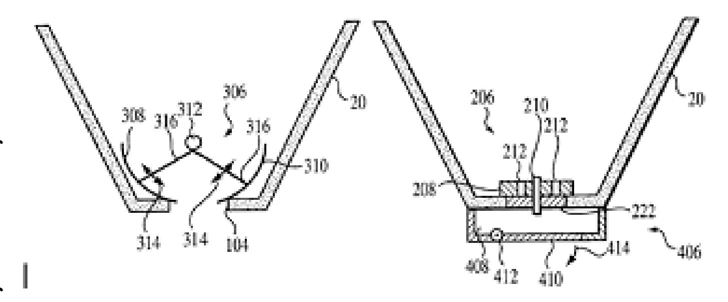
EP1053935 Method for extinguishing fires from an aircraft and related device. This method includes an aircraft with fire extinguishing device working with dual-phase – **liquide+gas** extinguishing stream flow. It has: liquid supply system, mixing chamber for the gas and the liquid and gas-dynamics nozzle. The pressure at the inlet of the nozzle as well the relative concentration of liquid in the flow are selected according to the conditions-dual–phase low dispersion and high-speed flow which has a high extinguishing–substance concentration.

FR2691366 Mobile vehicle for combating forest fires. A combined an all-purpose fire fighting mobile telecontrolled vehicle. It projects towards to fire

extinguishing water mixed with appropriate additives by one or more gas guns mounted on the vehicles an automatic rotating turret assembly.

FR2672223 Device intended for fire fighting and for the prevention of fires and pollution. A turbine system-air-born or on land vehicle, that may extinguish the fires by power gas stream or other extinguishing materials. It sprays over a great distance, aerosols and pulverized solids. The device can be converted into a flame **retarding-foam gun** simply by adding foaming substance in the circuits. The turbine pipe has within turbulence nozzles for spraying the fire suppressants.

US6125942 Aircraft-based fire-fighting bucket. A fire fighting air-born bucket system-suspended under helicopter has an opening for fire extinguishing retardant that is controlled by special valve-device, in order to assure desired volume flow rate of extinguishing materials. The area of the opening is **automatic controlled** in accordance with a schedule and initial amount of material in the bucket.



IT1241915 Sprinkler cannon for extinguishing forest fires. A sprinkler cannon– air-born by helicopter is producing atomized water powerful stream directed to the fire. It extinguishes the fire effectively.

2.2.4 Patents for the Ground-based extinguishment.

Patents from GROUP 4 refer to Ground-based extinguishing system.

US 3724554 Fire fighting system. It is a shielded vehicle- one or many, that may be remote controlled or with an operator. It sprays foamed water by nozzles and a pair of remote supply reel hoses. Hurricane fans are blowing the both air and foamed water such as fog to the fire.

FR2568779 Method for fighting forest fires. A vehicle is equipped at front with brush –clearing and scraping ground device. The extinguishing granular material-dust ,that is gathered from the ground is spraying by air pressure powered fans directly to quench the fire.

FR2652268 Armoured (shielded) vehicle for close-up intervention in forest fires in all terrains. A vehicle armoured combat tank type, which is special made and protected against direct flames and high temperatures. It is extinguishing the fire very closely to its zone by fire fighting equipment assembly on it. The tank–vehicle is suitable for difficult access terrain also.

US3635290 Apparatus for fighting forest fire. The invention comprises a plurality of sails (curtains),which are adapted to be erected by hot air balloon in the path of the fire. They are not flammable and they will intervene the flames and the fire to spread.

SU1834667 Method of fighting forest fire. Containers full with liquid fuel are charged on the ground near to the front of the fire. Small explosives disperse the fuel such as air-fuel mist. This cloud is ignited by another detonating explosion and the wave cleans the tree and bush foliage. That is preventing the fire propagation.

SU1697855 Method for preventing low forest fire from turning to upper forest fire. This method uses two explosions of rope shaped explosive charges putted the first one at 0,5-1 m altitude up the ground, and the second behind- 2, 2,5 m distance from the first one and on the ground. The time interval is 0,5-1 sec. between the explosions.

SU1657199 Method for forest fire fighting. A method extinguishes the forest fires by explosions at pyrolise temperature 575±175 K. The explosion occurs with both the charge and the flammable gaseous products from the vegetation pyrolisa process. The explosion wave demolishes the tree and bushes foliage and stops the fire propagation.

SU1799608 Equipment for quenching fringe of forest fire. A fire extinguishing device consisting big basket shaped body on the wheels and extinguishing products spay nozzles within. The device is associated to the vehicle. That device extinguishes predominantly steppe or terrain fires and fire fringe of forest fire.

WO0230515 Fire fighting system. An armored and temperature shielded tank shaped vehicle with sharp top part of the body and both water (extinguishing materials) tank inside and spray nozzle on it. The vehicle may penetrate forward to the fire flames and the vegetation obstacles and extinguishing the fire.

US5836398 Vehicle mounted fire-fighting system. A vehicle includes many motors, fire emergency protecting and shielded systems and covers, fire retardant discharge system, a plurality of swinging cutting elements and severe duty fire whips, a system of video, radar infrared sensors etc. The vehicle moves forward, once cut the burning vegetation is thrown aside by the whips that rotate to throw the debris back towards the fire, post-combustion air is blown at the burning debris to assist in extinguishing the fire and cleaning the path toward the vehicle. The system advances along the fire line.

US2003066659 Fire-fighting system having improved flow. An improved fire-fighting device uses an articulable boom arrangement and solid pipeline. It has high quenching agent flow rates and variable positioning of a quenching agent dispensing point.

2.2.5 Subsidiary systems, methods and equipment.
Patents from GROUP 4.1 refer to subsidiary systems, methods and equipment.

GB1135929 High expansion foam generator. A foam discharge apparatus having an air tunnel, a fan, inlet and outlet openings, plurality of liquid nozzles inside and hydraulic motor driven by the flow of foam-producing solution.

RU2184584 Pulsed unit. This one pneumatic-hydraulic assembly that is having working cylinders by pressured air and others by liquids. Their pistons move the piston rods of the others-hydraulic cylinders for propulsion the extinguishing liquids to the fire. The propulsion by the air expansion makes power extinguishing stream, and it is extinguishing more effectively the fire.

FR2627391 Forest fire-fighting method – uses water-filled tanks delivered by helicopter from strategically located-storage points. The system consists many air-born-by helicopters water-filled tanks preliminary located in the forest area. The helicopter takes by special hooks the water tanks, one by one and quickly pours them over the fire.

CHAPTER 4: FIRE FIGHTING AGENTS' SELECTION CRITERIA

4.1 Survey criteria

Survey criteria that determine the choice of fire fighting components and materials can most generally be classified into the following basic groups:

A/ Indication for short-term and long-term damaging effects on environment, flora and fauna, and human beings: environmental, toxicity and physiological effects; methods and means of protection.

B/ Criteria relating to fire-extinguishing efficiency of certain fire fighting agents, taking into consideration the complex specific characteristics of a particular fire; economical indicators.

C/ Product characteristics relating to transportation and handling operations, preparation of fire-extinguishing solutions and compositions, fire-fighting organization of the fire-fighting operation, as well as storage characteristics.

To provide a clearer picture and definition of survey criteria for the choice of fire fighting agents, a comparative table has been drawn up showing data derived from manufacturer's literature as follows: Fire Fighting Chemicals class A-COMPARATIVE TABLE, Publications such as: " Standard Test Procedures For the Evaluation of Wild-land Fire Products (USDA), standards etc. The table includes data for 12 compositions included in a USDA-US approved list of fire fighting agents for use in forest or wild-land fires. US-Standard NFPA No1150 "Fire fighting Foams for Class A Fuels in Rural, Suburban, and Vegetated Areas "/1999 gives the important criterion for the foams which are used much in fighting forest fires. These criteria are equally applicable to many other fire fighting products. Indicative characteristics of criteria /A, B, C/ characterising the product, as included in company literature, are as follows:

1. **Product**: Name, Ref.(Trade) No, Name of the company producer, general information. These data do not concern directly some of groups (A, B, C) but it is very important to know the producer, rate for the solutions, kind of the chemical, important hazard information. Products that can be used for fighting forest fires shall be commonly known, produced by recognised manufacturers and with approved usage permission; certified and/or passed a minimum level of testing in accordance with the requirements and limitations of a number of public, regional (state) and local standards and regulations - (Refer to groups A, C).
2. **Composition-** information on ingredients. This part of the information gives an idea of product composition and the expected effect of its application. For example, when a high percentage of Guar Gum, Attapulgus Clay, or any other kind of toxic chemicals are present, the suggested agent composition could be unacceptable to use in the specific situation and environmental surroundings.
3. **Hazards Identifications:** Emergency overview, Warning statements, Health effects- data on possible harmful effects on humans and animals; the extent of these effects/degree of harm, damage or disease, classification of important documentation related to possible harm/. Example: (Product No., Item No.) 11/3 dust in air max.0.05 Mg/m3; 12/3 125 mg/m3- Hexylene Glicol/

4. **First aid measures-** First aid measures and health precautions should also be indicated in case of over dosage of contact with the agent. For example: since the majority of chemicals are water soluble substances, general washing with continuous rinsing with water and exposure to fresh air should be most often be sufficient, as indicated in these product characteristics. (Group A)

5. **Fire fighting measures:** Flash point, hazardous product of combustion, extinguishing media, fire and explosion hazards. Data presented under this particular product characteristic relate to product handling operations before it is practically applied as a fire-fighting agent, as well as during transportation and storage, as well as during handling in the close vicinity of the fire. In general, products indicated as dangerous or harmful are not restricted from being applied as fire fighting agents and an appropriate indication of this is usually given by the manufacturer (for groups A. C).

6. **Accidental release measures** (To group A, C)

7. **Handling and storage** – Data on handling during storage and adequate protective measures for the personnel. (A, C)_

8. **Exposure control/personal protection:** eyes, skin, respiratory tract, ingestion, airborne exposure limits, OSHA PEL, AGGIH TLV – physiological effects. Given data concerned protection measures, limit total dust in air, Rat and Rabbit acute maximum dosage (LD 50) and hazard stage of the products. For example: product No11 requires respiratory ventilation if over 0,05 mg/m3, product No 10 is class 2A- cancerogen, product No 12 – dust limit is 125mg/ m3. (Group A, C)

9. **Physical and chemical properties-** specific gravity, powder, liquid or slurry, concentrate, foam, etc. Rate of chemical to solvent (usually this is water) is very important about use and method of application, cost etc. The viscosity is important to know for the specific application, pumps, apparatus. Whenever a judgment is to be made of the agent's applicability to a missile carrier or air-spraying method of fire extinguishing, the colouration of the agent's composition is also an important indicator, as well as a statistics piece of data relating to areas treated with fire retardants /Fire retardants/ etc. (Group B, C)

10. **Stability and Reactivity-** stability at normal condition, exposure temperature, avoid contacts with hazardous decomposition products and /or polimerization: Data on hazardous products that could result from actual performance situations, such as fighting open fires, or fire accidents in store houses and indoor storage areas. Normally, manufacturers indicate that these products are not very dangerous when chemical agents are used but providing information on these characteristics is a compulsory indicator. It is a well-known fact that many of these products could present a significant hazard when used in higher concentration levels (..Ammonia, Sulfur dioxide, Cyanides..) (These data refer to groups A, C).

11. **Toxicological information-** for dry product or its concentrate, eyes, skin, oral - range of toxicity and danger, acute limits to Rabbits and Rats (LD50). (Group A)

12. **Ecological information** – environmental impact (protection): It refers to aquatic life and animals such as: Acute toxicity (LD50 – 96 Hr) to: Juvenile Rainbow Trout, Bobwhite qualy, Mallard duck and others. (Group A)

13. **Disposal considerations -** Information about discarded and spilled materials, consideration of state or local regulations. (Group A, B)

14. **Transportation – US DOT –** Concerns the hazards associated with transportation of the product and legal documents and regulations**. (A, B, C)**

15. **Regulatory Information: TSCA, DSI, WHMIS, SARA, CERCLA** classifications, notification etc. refer to the laws and specific regulations. Some categories of products may be forbidden for use. Listed products have legal certificates for normal use. (A,B, C)

16. **Other information** – refer to some regulations (NFPA-rating, HMIS). It may seem immediately applicable to health, fire, reactivity or additional information for the hazards of use (A, C).

    According to the 1150 Standard on foams, classification and values are also supplied for the following significant indicative characteristics:

17. **Biodegradability** -table 3-2.3. A minimum of 60 % biodegradation shall be obtained within 42 days (Gr. A)

18. **Mammalian Toxicity**- The foam concentrate shall not exceed the toxicity limits …(For example Oral LD_{50}> 500 mg/kg, dermal >2000 mg/kg …etc. table 2-1.1.1.) (Gr. A)

19. **Miscibility-** The concentrate, at the specified dilutions, shall be **miscible in water at 21°C**. (Gr. B, C)

20. **Pour point-** The pour point of the concentrate shall be **less than 35°F …** (Gr. B, C)

21. **Corrosion and Materials Compatibility: Uniform corrosion, Compatibility with Nonmetallic Materials:** PVC plastics, Mil-S-8802 sealant,..teflon AMS 3660…(p. 1150-5 standard) (Groups B, C)

There are several very important points for evaluation of a chemical effectivity: (Criteria data Group B)

22. **Surface Tension (**of foam solution s, at 0,3 and 1,0%- is determined in accordance with ISO 304 standard /p. 3-3.6 page 1150-8/) Pure water has a surface tension of about 73 dynes/cm, alcohol 22 d/cm. * p. 364:**For fire fighting, additives are recommended in concentration to reduce surface tension from 30 to 35 dynes /** Note: * "Forest Fire Control and Use"- Kenneth P. Davis/59- Book, Chapter 13/

23. **Wetting Ability: *(p.363):" Wetting fuels immediately in advance of a fire makes them temporarily non available for combustion.** Because of its high specific heat, water is efficient in decreasing the ignitibility of fuels by absorbing so much heat that fuels cannot be brought to an ignition temperature".

24. **Drain Time- 25%** of the total solution that is contained in the foam to revert to liquid and drain out of the bubble structure. (1150-4)

25. **Expansion** (or Expansion Ratio), The ratio of the volume of the foam in its aerated state to the original volume of the non-aerated foam solution. (1150-4)

4.2 Conclusions

A significant portion of all data supplied by manufacturing companies on fire fighting products relate to safety criteria during transportation, preparation, storage and actual use of these agents for fighting forest fires. Important data on the composition, toxicity, possible eventual immediate and long-term harm to the health of humans and animals exposed to the influence of the agents is also provided, as well as information on the overall harm to surrounding environment: vegetation, water resources and soil.

This data, as well as data relating to the specific situation, are of primary significance to the choice of a suitable fire fighting product or chemical agent The EFFICIENCY and economic expediency of the choice for the suitable product are mostly related to the comparative analysis and selection of a significant number of chemical and physical indicative characteristics, as mentioned above. Additionally, the choice is also influenced by equipment, resources and techniques adopted for fighting the specific fire. WATER is a major fire-fighting agent used for fighting forest fires, but various foams and other products have also been widely applied recently. One litre of water is specified as capable of extinguishing 300 kg / (Fons, 1950, p. 363) / fully burning wooden material. Practically, this ratio is 1:50 due to evaporation. On the other hand, foam is more expensive but the quantities required are far less than above (Fons, 1950, p. 367).

Low expansion foam produces 16- 18 gallons of air foam per gallon of water. The foam solution is 6:94 (gallons foam/ gallons water). Due to their lower surface tension characteristics these materials achieve significantly better wetting effects and prolonged action compared to water **/p.24 Drain time/.** On the other hand, foams scatter significantly when sprayed from above using aviation means or missile carriers, which is due to their low specific gravity and bubble-type configuration /**p.25 Expansion/. Water is a preferred agent** to foams for fighting small fires and for immediate initial attack. Foam is not recommended for direct attack on forest, bush, and Grass fires.

Water is especially valuable on small fires (Fons, 1950, p. 367). Despite of all said above, the use of foams, gels, powder agents, etc. is very often preferred in areas of hard access and lack of sufficient readily available water resource. /Often used products include "Vermiculit", Sodium Calcium Borate, etc./ The agent is usually delivered to the site of the fire via air. Due to the adoption of Fixed-Wing Air crafts, Helicopters with Fixed Tanks, Ground Engines and Helicopters with Buckets, characteristics mentioned in **p.21 Corrosion and Materials Compatibility** should be carefully checked and compared in addition.

4.3 A carrier's body capable of delivering fighting agents, launched from a kilometrical distance to the fire zone.

The need of delivering forest fire-extinguishing mixtures to places of hard access where it is impossible or rather costly to extinguish fires, using conventional methods calls for designing a new carrier's body to deliver the above agents into the fire zone. This need has created the problem's solution. To model and design a carrier's body capable of delivering fighting agents, launched from a kilometrical distance, to the fire zone.

It has been assumed that a fire fighting system of quick action at the fire initiation locations can provide great help for immediate fire put out, using fairly small volumes of extinguishing agents. Based on this innovative, undeveloped system, detailed design of

design variants will take place. This is the **basic assumption** in which the writer's decisions have been based.

The **objectives** of such an investigation were related to the following:

1. Determine the optimal height of spraying the fire-extinguishing agent, its type and quantity.
2. Studying carrier's movement, through further modelling of the body as a set of mass particles and its dynamic characteristics.
3. Strength calculations for the carrier body necessary to establish the amount of pressure required to split the body into its constituent parts, especially in the critical section area.
4. Defining the technical, chemical and environmental requirements for the fire extinguishing agent.
5. *Optimisation* in achieving the optimum effective carrier capacity for the transported agent.
6. Determination of the minimum number of carriers required for the extinguishing of a specified bio-mass area.
7. Calculating carrier's optimum aerodynamic coefficients.
8. Efficiency analysis: carrier's accuracy of hitting, analysis of extinguishing. Efficiency, study on the height at which the fire-extinguishing agent is required to explode.
9. Determine carrier's size and inertia momentums from the body's movement through air drifts, using mathematical and 3D modelling.
10. Provide a technological solution to the process of filling the fire-extinguishing agent into the carrier.
11. Experimental launching to determine the drift characteristics and the normal deviation.

Basic carrier parameters and characteristics will be defined following a number of experiments. The scope of the physical experiment will exceed the scope of the numerical experiment because of the large number of unstudied factors affecting the efficiency of the fire extinguishing process.

4.3.1 Numerical Experiment

It is necessary for the purpose of the preliminary study to define the effect of basic parameters on carrier characteristics. Two main groups of experiments are envisaged to study the following factors:

a. Carrier fairing by surrounding air: its focal point and coefficients of aerodynamic forces and momentums. The numerical method to be used for this experiment will be the finite element method.
b. Carrier movement along its trajectory: The characteristics of carrier movement along its trajectory are defined, along with the effect of surrounding environment on these characteristics. The numerical method to be used for this particular type of experiment is the *Runge – Cutta* method.

Mathematical models of the carrier will be created in the course of the design process and various variants within the allowable solutions will be studied by means of the numerical experiments. An optimisation procedure will be applied to determine the parameters of the variant which best satisfies a preset criterion.

4.3.2 Physical Experiment

In an aerodynamic laboratory

Experiments with carrier test dummies will be run in the aerodynamic trough and these will be used to determine the following:

- coefficients of aerodynamic forces;
- coefficients of momentums;
- the focal point of aerodynamic forces;
- the centre of pressure.

Experiments will be carried out for various velocities and angles of fairing in order to determine their relationship with parameters listed above.

To ensure visibility of the whole process the following tools will be used for the present experiment: inter-model, 6-component strain scales; micro hot-wire anemometers and smoke generators.

The aerodynamic trough is equipped to allow a controlled experiment to be carried out, thus ensuring that maximum information is derived from a single experiment. The $\alpha - \beta$ mechanism allows us to vary the angle of launching and the sliding angle, and the coordinate measuring unit allows us to measure flow velocity and pressure at various points from the velocity range of the flow. The experiment is controlled by means of a computer and angles and coordinates are varied in accordance with a preset routine. Control signals are transmitted from the computer to the actuators by means of a digital-to-analogue converter and signals received from sensors are converted by means of an analogue-to-digital converter and are then saved in a magnetic media.

Preliminary and secondary processing of experiment results is carried out by a specialised software application.

Trials on various shapes of test dummies will help define the shape of the carrier that will best meet the optimisation criterion requirements.

Thrust measurement stand

Experiments to be carried out on a strain measurement stand will help measure engine thrust. The amount of rocket engine thrust while the engine is in operation is recorded by the stand. A group of experiments will be used to study the effect of initial temperature on engine thrust.

Data recorded by strain measurement sensors is converted via an analogue-to-digital converter and is then recorded in a magnetic media.

The final result of the above operation will be the relationship between:

- thrust variations and time; and
- thrust variations and initial temperature.

4.3.3 Field Tests

Basic carrier parameters and characteristics will be defined through field test experiments. The amount of explosive, required to split the carrier for spraying the fire extinguishing agent, will be determined through test stand experiments. These experiments will also be used to determine the relative speed of separating individual sections of the carrier using frames and a conductor wire positioned in accordance with a specific layout diagram.

The optimum height of spraying the fire-extinguishing agent will need to be defined through several firing operations involving different heights of carrier splitting, and measuring the density of agent coverage over the specific surface area.

Trajectory tests will have to be carried out using a group of carriers and camera photo-theodolites will be used to make a record of their coordinates at various points along their trajectories. Camera photo-theodolites will be positioned at the vertexes of a triangle to ensure high precision of readings for their spatial coordinates. The results of the above experiments will be used to finally define basic carrier parameters.

*Firing **accuracy** and side drift characteristics will be defined following the processing of data on splitting point coordinates.*

*Firing **efficiency** in fighting large areas of fires will be determined by means of measuring the spreading and density coverage of the agent over the specified surface area resulting from an artificial spreading caused in a test firing process.*

Processing of all results from field tests will be carried out using a specially designed software application to ensure maximum information is available.

3.3.3 End Proof Laboratory Experiments on the Carrier.

Before the product is made available for serial production and operation it will be necessary to provide sufficiently reliable proof of complete compliance of carrier design structure and parameters, and the requirements specified in the initial assignment. This proof shall be based on facts derived as a result of a set of laboratory tests and field tests. Experimental additional clarifications to the design and demonstration of how all requirements stated in the initial assignment have been met, are both completely economically justified, since these avoid possible accidents, harmful effects on surrounding environment or any principal changes in the course of serial production and operational performance.

The unique nature of the carrier allows for all experiments described in the present chapter to be carried out using only specialised laboratory equipment designed to specifically test such kind or products (or similar).

These stands shall be equipped with all necessary precise measurement units(hydraulic and pneumatic stations, temperature and pressure chambers), measuring sets providing facilities to measure various physical parameters – mass, time, temperature, pressure, linear and angular deviation, velocity and acceleration, linear elongation, etc. Another significant requirement is that provision is made for modern systems for acquisition, storage, analysis and visual representation of measurement data, as well as for suitable equipment for chemical and microscopic analysis and flaw detection.

4.3.4 Cold control & process tests

It will be necessary at the trial run production stage to determine the effect of various production and technical factors over the design structure of the fire-extinguishing carrier. The suitability of selected design solutions and technological processes shall be checked via a set of various cold control and in-process tests, as described underneath.

I. Static tests

I.1. Hydraulic tests for carrier strength and air-tight characteristics when internal pressure is available

To check the design strength and air-tight characteristics of the carrier 2 or 3 randomly selected carriers from the trial run batch are tested (their parameters are in compliance with the initial task assignment) with an internal pressure load leading to destruction. For the purpose of these first tests it will be necessary to perform strain measurements (using a strain measurement device) on certain sections of the carrier where strain and deformation is of highest significance.

I.2 Static strength tests for carrier loads of various calculation situations

It is envisaged under these tests to determine in detail the actual state under strain and the deformation state of individual carrier sections, by means of performing strain measurements for loads applied close to actual loads (experienced during various stages of the flight, during transportation, handling and preparation for launching, storage, etc.). It will be possible to simulate not only the internal pressure present in the engine chamber, but also, using inflating rubber muffs, the fairly unevenly distributed external surplus pressure applied by aerodynamic forces, and additionally use elastic levers and belts to simulate local loads.

I.3 Static strength tests of solid engine fuel

Solid fuel for rocket engines is an element of their design structure and therefore it is necessary to be aware of its mechanical characteristics.

The most commonly applied method of determining mechanical characteristics of solid fuel is the single-axis tension test. The test is carried out using standard samples (in accordance with the JANAF standard in USA, for example), made by means of casting, stamping or milling. Tests in complex strain state situations could also be performed when this is considered necessary.

II. Dynamic tests

II.1 Low cyclic fatigue tests of the carrier

The purpose of this type of test is to determine carrier strength characteristics under pulsating in a sinusoidal cycle internal pressure present inside the combustion chamber, its parameters having been defined during trial firing operations of the rocket engine using solid fuel.

II.2 Shock load tests of the carrier

This type of test studies the strength characteristics of the carrier under shock load conditions during flight, transportation or various ground-level handling operations.

II.3 Solid fuel tests under regular variable load

This type of test provides information on the vibrational and high-elasticity characteristics of the fuel. Damping characteristics and fatigue strength of the solid fuel are studied under pulsating loads of exhaust gas pressure.

4.3.5 Temperature tests

The purpose of these tests is to define variations in mechanical characteristics of the material of the structure, bonded connections, sealings and protective coatings.

I. Temperature tests of the fire-extinguishing carrier

Temperature bands in various sections of the carrier body are defined, along with air-tightness characteristics and the efficiency of thermal protection against aerodynamic heat-up and engine combustion gas heat. The test is carried out in a temperature chamber and temperature measurement are taken in most thermally loaded sections of the structure of the carrier. Mechanical and chemical variations in the materials used for the structure of the carrier are studied, along with variations in solid fuel characteristics and fire-extinguishing agent characteristics resulting from the applied thermal load.

II. Temperature tests of the fuel and the fire-extinguishing agent variations resulting from temperature variations in surrounding environment

Temperature strain in the fuel, the fire-extinguishing agent and the protective coating result from temperature variations in surrounding environment during long storage conditions and this is caused by the low temperature conductivity exhibited by the fuel and the fire-extinguishing agent. To define the temperature band in the fuel and the fire-extinguishing agent we use temperature measurement sensors. Also studied here are the mechanical and chemical variations occurring in the fuel and the fire-extinguishing agent.

4.3.6 Firing stand tests

These tests constitute the largest portion of the overall scope of tests performed on the fire-extinguishing carrier.

I. Combined tests in actual engine operation conditions

The firing test stand shall provide possibilities for measuring engine thrust, combustion chamber temperature and pressure, and strained and deformation state of the structure during the fuel combustion process. All results are obtained as real-time readings during actual engine operation until the fuel is completely burned out.

II. Tests of the fire-extinguishing agent spraying system

This type of test consists of studying the efficiency of the fire-extinguishing agent spraying system. In general, the real values of such parameters as surface area (cubic content) of effective coverage of the fire-extinguishing agent has to be defined, as well as the distribution of fire-extinguishing agent concentration in the point of spraying, etc.

A detailed analysis is to be undertaken in all cases of any abnormal behaviour of the carrier structure and functional systems within the fire-extinguishing carrier during all types of tests, such as, for example, destruction resulting from strain loads lower than specified, significant residual deformation, various chemical reactions or functional disorders leading to dangerous effects on surrounding environment, human health and life, etc., and the causes leading to such abnormal behaviour shall be studied. Such studies might involve microscopic analysis, non-destructive analysis and chemical analysis, as well as other commonly known scientific methods and approaches.

ISO standards:

ISO/TR 7248: 1985 Fire data - Collection and presentation system.

ISO 8421-1: 1987 Fire protection - Vocabulary -- Part 1: General terms and phenomena of fire.

ISO 8421-2: 1987 Fire protection - Vocabulary -- Part 2: Structural fire protection.

ISO 8421-4: 1990 Fire protection - Vocabulary -- Part 4: Fire extinction equipment.

ISO 3941: 1977 Classification of fires.

ISO/TR 13387-4: 1999 Fire safety engineering -- Part 4: Initiation and development of fire and generation of fire effluents.

SAE AIR 1855A, Actuation System Data Summary for Missiles and Launch Vehicles, Publication date: 1995-08-01.

Draft standard) Explosives for civil uses - Propellants and rocket propellants - Part 5:

Solid rocket propellants - Guide for the determination of voids and fissures,

Publication date: 2002-04-01.

Report: "Wildland Fires: Initiation, Spread, Suppression and Ecological Consequences", 5th International Scientific Conference, 30 June – 5 July 2003, Krasnoyarsk Region, Russian Federation

Organizers:

- Tomsk State University (Center of Education and Research on Reactive Media Mechanics and Ecology) (Tomsk);
- Siberian Branch of All-Russian Institute of Fire Prevention Defense, Ministry of Home Affairs, Russian Federation (Krasnoyarsk);
- Siberian Branch of the Council on Combustion and Explosion of the Russian Academy of Science (RAS) (Novosibirsk);
- Regional Public Organization «Tomsk Society of Mechanical Scientists and Thermo Physicists» (Tomsk).

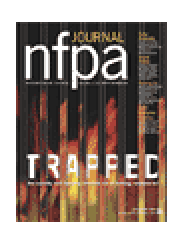
ISO/TR 13387-3:1999 Fire safety engineering -- Part 3: Assessment and verification of mathematical fire models

ISO 7203-1:1995	Fire extinguishing media -- Foam concentrates -- Part 1: Specification for low expansion foam concentrates for top application to water-immiscible liquids
ISO 7203-2:1995	Fire extinguishing media -- Foam concentrates -- Part 2: Specification for medium and high expansion foam concentrates for top application to water-immiscible liquids
ISO 7203-3:1999	Fire extinguishing media -- Foam concentrates -- Part 3: Specification for low expansion foam concentrates for top application to water-miscible liquids
ISO 8421-1:1987	Fire protection -- Vocabulary -- Part 1: General terms and phenomena of fire
ISO 8421-2:1987	Fire protection -- Vocabulary -- Part 2: Structural fire protection
ISO 8421-4:1990	Fire protection -- Vocabulary -- Part 4: Fire extinction equipment
ISO 8421-8:1990	Fire protection -- Vocabulary -- Part 8: Terms specific to fire-fighting, rescue services and handling hazardous materials
ISO 13943:2000	Fire safety – Vocabulary

CHAPTER 5: FIRE BEHAVIOUR DATA SOURCES

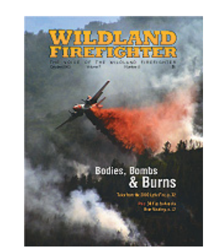
5.1 Fire Behaviour: Primary sources

Periodicals



1) ***NFPA Journal®*** is NFPA's official, award-winning bimonthly membership magazine, reaching the Association's more than 75,000 fire protection and fire service professionals. Covering major topics in fire protection and suppression, *NFPA Journal* carries fire investigation reports; annual NFPA statistical studies on large-loss fires, multiple-death fires, U.S. fire loss and firefighter deaths and injuries; articles on fire protection advances and public education; and other information of interest to NFPA members

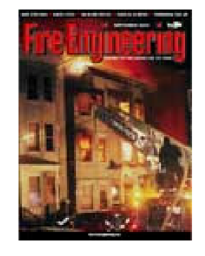
2) Publisher**:** Natl Fire Protection Assn; ISBN: 9992419423



3) ***Fire Technology,*** a quarterly, peer-reviewed, technical journal, reaches some 3,000 international subscribers interested in receiving information about the scientific and technical aspects of fire and fire protection.

4) ***Wildland Firefighter magazine***

5) Publisher: Deer Valley Pr; ISBN: 1931301158



6) ***Fire Engineering***

7) *Fire protection engineering*. Cleveland, OH. 2002-

8) *Fire technology*. Boston.

9) *Fire command*

10) Fire and materials. London. 1(1976)

11) Fire prevention: A guide for management : FPA journal, Publisher: Fire Protection Association

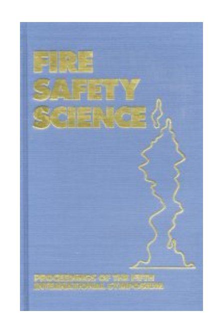
12) Fire safety journal. Oxford, Publisher: Society of Fire Protection

13) Reference Materials

14) The Fire chief's handbook.

15) Fire protection handbook
16) ***National fire codes***. (National Fire Protection Association)
17) ***National Fire Protection Association Directory*** (annual)
18) U.S.Fire Administration. ***Federal Emergency Management Agency Documents***
19) U.S. Fire Administration. ***Technical Report Series***

20) Conferences & Symposiums proceedings



21) 5th International IAFSS Symposium Proceedings
22) 3-7 March, 1997, Melbourne, Australia
23) Editor: Y Hasemi
24) Hardback, pp1396, ISBN 4 9900625 5 5

25) Interflam 1999
26) Proceedings of the 8th conference, Publication date: July 1999,
27) ISBN 0 9532312 1 6 (Set).



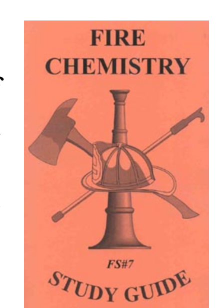
28) Fire Research and Engineering: Third International Conference 5 October, 1999
29) Publisher: Technomic Publishing Co; ISBN: 1566768888
30)

5.2 Fire Behaviour: Secondary data sources

1). Kuo, K. K. (1986) ***Principles of Combustion***, John Wiley and Sons, New York.

2). Cathy Cobb, Harold Goldwhite ***Creations of Fire: Chemistry's Lively History from Alchemy to the Atomic Age***, Perseus Publishing; (September 1995) ASIN: 0306450879

3). Russell G. Wright, ***Fire!: An Event-Based Science Module Teacher's Guide***, Pearson Prentice Hall, Published Date: 12/01/2001, ISBN: 0769023495,



4). FS#7: ***FIRE CHEMISTRY***. Study Guide: This BOOKLET covers the chemistry of fire, including ignition temperatures and properties of flammable and combustible materials, flame and smoke spread, and products of combustion. Information covers: Science, Vapor-Gases, Ignition Temperature, Flash-Point & Fire Point, Heat & Heat Transmission, Spontaneous Ignition, Oxidation, Fire Stages-Backdrafts-Combustion, Fire Extension, and Explosions.

5). ***Interflam 1999***, Proceedings of the 8th conference, Publication Date: July 1999
Details: Hardback (2 Vol), casesewn, 1477pp, with 239 tables and 719 illustrations, ISBN 0 9532312 1 6 (Set).

The eighth conference was held in Edinburgh, 28th June - 1st July.

6). Byram, G. M. 1963. ***Combustion of forest fuels***. In: Forest fire. Control and use (K.P. Davis, ed.), 61-89. McGraw Hill, New York.

7). ***Principles of fire behaviour***, James G. Quintiere, Delmar Publishers

8). Joseph Lowe, ***Wildland Firefighting Practices***, First Edition

9**).** Fire Codes and Related Materials

10). Margaret Fuller, *Forest Fires: An Introduction to Wildland Fire Behavior, Management, Firefighting, and Prevention*. New York: John Wiley and Sons, 1991.

11). Mannan M. S., A. A. Aldeeb, and W.J. Rogers ***Understanding the Role of Process Chemistry in Fires and Explosions,*** Mary Kay O'Connor Process Safety Center

Chemical Engineering Department
Texas A&M University
College Station TX 77843-3122
Email: mannan@tamu.edu

This paper provides a structured approach for chemical reactivity hazard evaluation using computational methods coupled with experimental techniques. This systematic approach helps to minimise experimental work and identifies the most important parameters in evaluating process fire and explosion hazards and provides a more comprehensive understanding of process chemistry.

12) NFPA 921 ***Guide for Fire and Explosion Investigations****, 1998, Edition*, copyright ©, National Fire Protection Association, 1998. For more information, contact: The NFPA Library at (617) 984-7445 or e-mail library@nfpa.org

13) S. J. McNaughton, N. R. H. Stronach, and N. J. Georgiadis. 1998. ***Combustion in natural fires and global emissions budgets***. Ecol. Appl. 8: 464-468.

14). Robinson, J.M., ***Problems in global fire evaluation: is remote sensing the solution***.

15). ***Global Biomass Burning. Atmospheric, Climatic, and Biospheric Implication***. Ed. J.S. Levine, MIT Press, Cambridge, Massachusetts, 67-73, 1991.

16). ***A Heat Transfer Textbook***, 3rd edition, John H. Lienhard IV, Professor, University of Houston John H. Lienhard V, Professor, Massachusetts Institute of Technology , Copyright (c) 2000-2003;

20). Edward A. Johnson (Editor), Kiyoko Miyanishi (Editor), ***Forest Fires: Behavior and Ecological Effects,*** Publisher: Academic Press; (January 2001), ISBN: 012386660X

21). Leonard F. DeBano (Author), Daniel G. Neary (Author), Peter F. Ffolliott (Author), ***Fire Effects on Ecosystems*** , Publisher: John Wiley & Sons; (March 1998), ISBN: 0471163562

22). Stephen F. Arno, Steven Allison-Bunnell, ***Flames in Our Forest,*** Publisher: Island Press; (May 2002), ISBN: 1559638826

23). Lee E. Frelich (Author), ***Forest Dynamics and Disturbance Regimes : Studies from Temperate Evergreen-Deciduous Forests***, Publisher: Cambridge University Press; (March 2002), ISBN: 0521650828

24). Bovio G., Bovo G.: Analysis of fire preventive silvicultural interventions based on the evolution of the concept of "allowable burned area, Valencia, ICONA, Madrid, 1988.

25). Countryman C.M.: Project nambeau, an investigation of mass fire (1964-1967). Final report. Pacific Southwest Forest and Range Exp. Sta. 68, 1969.

26). Magliacani G.: Forest fires and the prevention of burns: study and development of a protective outfit. Annals of the MBC, Palermo, 1: 67-69, 1988.

27). Dickinson, M.B. and E.A. Johnson. 2001. Fire effects on trees. Chapter 14 In: Forest Fires: Behavior and Ecological Effects. (Johnson, E.A. and K. Miyanishi, eds)., Academic Press, San Diego, pp. 477-525.

28). Combustion and flame : the journal of the Combustion Institute. - Volume 128, 3, 2002

29). *Fire safety journal* [electronic resource]. - Elsevier Science. - S0000984MP

30). *Fire service statistics*. - London : Chartered Institute of Public Finance and Accountancy. - 0968-0357

31). *Combustion and flame* [electronic resource]. - New York : Elsevier Science Inc. - S0001690MP

32). Greek Statistics office http://www.statistics.gr/gr_tables/hellas_in_numbers.pdf

33). Combustion science & technology

34). Journal of Fire Engineering

35). Academic press website

Extinguishing methods for forest fire behaviour prediction

ECE FAO ILO; *Seminar on methods and equipment for the prevention of forest fires*. Valencia (Spain), 1986.

Magliacani G.: *Forest fires and the prevention of burns: study and development of a protective outfit*. Annals of the MBC, Palermo, 1: 67-69, 1988.

Wilson C.: *Detection and control of forest tires for the protection of the Human Environment: Proposal for a Global Programme FAO*. Doc. Mr/6387/ E 1. 76/1-150. Rome, 1975.

George, C.W. 1992. *Improving the performance of fire retardant delivery systems on fixed-wing aircraft*. Research Note INT-400. U.S. Forest Service, Intermountain Research Station, Missoula, MT.

America's Fires: Management on Wildlands and Forests, Stephen J. Pyne / Paperback / Forest History Society, Incorporated / March 1997, ISBN: 0890300534

Forest Fires: An Introduction to Wildland Fire Behavior, Management, Firefighting, and Prevention, Margaret C. Fuller / Paperback / Wiley, John & Sons, Incorporated / May 1991, ISBN: 0471521892

Bovio G., Bovo G.: *Analysis of fire preventive silvicultural interventions based on the evolution of the concept of "allowable burned area"*. Documentos del seminario sobre metodos y equipos para la prevenci6n de incendios forestales, Valencia, ICONA, Madrid, 1988.

M. H. Jo, M. B. Lee, K. D. Bu, S. R. Baek, 2000. ***The Construction of Forest Fire Monitoring, System using Internet GIS and Satellite Images***, *Proceedings of International Symposium on Remote Sensing*, pp.61-64.

M. H. Jo, M. B. Lee, S. Y. Lee, Y. W. Jo, S. R. Baek, 2000. ***The Development of Forest Fire Forecasting System using Internet GIS and Satellite Remote Sensing***, *Proceedings of The 21st Asian Conference on Remote Sensing*, pp.1161-1166.

M. H. Jo, K. Lee, J. B. Kim, J. S. Oh, S. H. Yeon, 2001. ***Validation Method of Damaged Area by Pine Wilt Disease (Bursaphelenchus Xylophilus) using High Resolution Images and GPS***, *International Symposium on Remote Sensing 2001.*

M. H. Jo, Y. W. Jo, J. S. Oh, S. Y. Lee, 2001. ***Agent-Based Dynamic Load Balancing, Method on Web GIS: Forest Fire Information System***, *Urban and Regional Information System 2001.*

Greece: Conference Conclusions: ***Fires in the Mediterranean Forests - Prevention - Suppression - Soil Erosion - Reforestation*** (IFFN No. 20 - March 1999), The 1st International Scientific Conference on "Fires in Mediterranean Forests: Prevention - Supression - Soil Erosion - Reforestation", Athens, Greece, 3 - 6 February 1999, (IFFN No. 20 - March 1999,p. 88-90)

Wildland Fire Safety Summit and IV International Conference on Forest Fire Research (18-23 November 2002, Coimbra, Portugal)

Fourth International Workshop Remote ***Sensing and GIS Applications to Forest Fire Management: Innovative concepts and methods*** (5-7 June 2003, Ghent University, Ghent, Belgium).

XII World Forestry Congress, 21-28 September 2003, Québec City, Canada. http://www.wfc2003.org/

The 3rd International Conference on Wildland Fire (October 2003, Sydney, Australia).http://www.wildlandfire03.com/home.asp

Fire extinguishing media

Chemicals for Forest Fire Fighting, National Fire Protection Association, Forest Committe / Paperback / National Fire Protection Association / December 1977 ISBN: 0877651043

Her Majesty's Fire Services Inspectorate, Publication: Fire Service Manual Volume 1, Title: *Fire Service Technology, Equipment and Media,* Subtitle: *Physics and Chemistry for Firefighters,* ISBN: 0-11-341182-0, Copyright © 2003: Queen's Printer,Victoria, British Columbia, Canada

Forest Practices Code of British Columbia and Employment Standards Acts, *Forest fire prevention and suppression regulation*, Deposited April 12, 1995, effective June 15, 1995

Norecol Environmental Consultants LTD. 1989. *Toxicological review of fire fighting foams*. File 1-091-02.01, Fire Management Forest Protection Branch, Ministry of Forests and Lands, Victoria, BC, Canada.

Blahm, T.H. and G.R. Snyder. 1973. ***Effect of chemical fire retardants on the survival of juvenile salmonids.*** Report 53500-CT2-85(N) 1973, U.S. Bureau of Land Management, Denver, CO.

Monsanto Company. 1990. ***Phos-Chek WD-881 fire suppressant foam fact sheet***. Monsanto Wildfire Division, Ontario, CA, USA.

Ansul Fire Protection. 1991. ***Extinguishing Agent Data Sheet***, Silv-Ex "Class A" fire control concentrate. Ansul Fire Protection, Marinette, WI, USA.

Schlobohm, P. and R. Rochna. 1988. ***An evaluation of foam as a fire suppressant is available***. In *Foam Applications for Wildland and Urban Fire Management*, Vol. 1. U.S. Department of Agriculture, Wahington, DC.
Tauni Andstén, Olavi keski-Rahkonen, Jukka Myllymäki, ***Bursting potential of portable fire extinguishers at elevated temperatures,*** VTT RESEARCH NOTES 2200, Publisher: VTT Tietopalvelu, 2003, **ISBN**:951-38-6153-8

Standards

BS EN 1568-1:2000 Fire extinguishing media. Foam concentrates. Specification for medium expansion foam concentrates for surface application to water-immiscible liquids.

BS EN 1568-2:2000 Fire extinguishing media. Foam concentrates. Specification for high expansion foam concentrates for surface application to water-immiscible liquids.

BS EN 1568-3:2000 Fire extinguishing media. Foam concentrates. Specification for low expansion foam concentrates for surface application to water-immiscible liquids.

BS EN 1568-4:2000 Fire extinguishing media. Foam concentrates. Specification for low expansion foam concentrates for surface application to water-miscible liquids.

BS EN 12094-5:2001 Fixed firefighting systems. Components for gas extinguishing systems. Requirements and test methods for high and low pressure selector valves and their actuators for CO_2 systems.

BS EN 12094-6:2001 Fixed firefighting systems. Components for gas extinguishing systems. Requirements and test methods for non-electrical disable devices for CO_2 systems.

BS EN 12094-7:2001 Fixed firefighting systems. Components for gas extinguishing systems. Requirements and test methods for nozzles for CO_2 systems.

BS EN 12094-8:1998 Fixed firefighting systems. Components for gas extinguishing systems. Requirements and test methods for flexible connectors for CO_2 systems.

BS EN 12094-13:2001 Fixed firefighting systems. Components for gas extinguishing systems. Requirements and test methods for check valves and non-return valves.

BS EN 12259-1:1999 Fixed firefighting systems. Components for sprinkler and water spray systems. Sprinklers.

BS EN 12259-2:1999 Fixed firefighting systems. Components for sprinkler and water spray systems. Wet alarm valve assemblies.

BS EN 12259-3:2000 Fixed firefighting systems. Components for sprinkler and water spray systems. Dry alarm valve assemblies.

BS EN 12259-4:2000 Fixed firefighting systems. Components for sprinkler and water spray systems. Water motor alarms.

BS EN 12416-1:2001 Fixed firefighting systems. Powder systems. Requiremments and test methods for components.

BS EN 12416-2:2001 Fixed firefighting systems. Powder systems. Design, construction and maintenance.

BS EN 25923:1994 BS 6535-1:1990 ISO 5923:1989 Fire extinguishing media. Carbon dioxide.

References

1. SAMPSON, R.N., ed., ATKINSON R.D., ed., and LEWIS, J.W., ed., 2000. *Mapping Wildfire Hazards and Risks.* 1st ed. (s.l.): Food Products Pr.

2. ERTEL, M., and BERK G.C., 1998. *Firefighting: Basic Skills and Techniques.* (s.l.): Goodheart-Willcox Co.

3. LOWE, J.D., 2001. *Wildland firefighting practices.* Albany, NY: Delmar.

4. JOHNSON, E., 2001. *Forest Fires: Behavior and Ecological Effects.* (s.l.): Academic Press.

5. MACLEAN, J.N., 1999. *Fire on the mountain: the true story of the South Canyon fire.* New York: William Morrow.

6. GOODSON, C., ed., and ADAMS, B., ed., 1998. *Fundamentals of wildland firefighting.* 3rd ed. Stillwater, Oklahoma: Fire Protection Publications, Oklahoma State University.

7. WIEDER, M., ed., SMITH, C.M., ed., and BRAKHAGE, C., ed. 1996. *Principles of Foam Fire Fighting.* 1st ed. Stillwater, Oklahoma: Fire Protection Publications, Oklahoma State University.

8. FULLER, M., 1991. *Forest Fires: An Introduction to Wildland Fire Behavior, Management, Firefighting, and Prevention (Wiley Nature Editions).* (s.l.): John Wiley & Sons.

9. PYNE, S.J., ANDREWS, P.L., and LAVEN R.D., 1996. *Introduction to wildland fire.* 2-nd ed. (s.l.): John Wiley & Sons.

10. DAVIS, K.P., 1959. *Forest fire: Control and use.* New York: McGraw-Hill Book Company, INC.

11. LINVILLE, J.L., managing ed., et. al., 1991. *Fire protection handbook.* 17-th ed. Quincy, Massachusetts: National Fire Protection Association.

12. LINVILLE, J.L., managing ed., et. al., 1995. SFPE *Handbook of fire protection engineering.* 2-nd ed. Quincy, Massachusetts: National Fire Protection Association.

13. VAN NAO, T., ed., 1982. *Forest fire prevention and control.* The Hague: Martinus Nijhoff / Dr. W. Junk Publishers.

14. QUINTIERE, J.G., 1991. *Principles of fire behavior.* 1st ed. (s.l.): Delmar Learning.

15. SCHROEDER, M.J., and BUCK, C.C., 1970. *Fire weather.* Washington: U.S. Government Printing Office.

Patents

16. Europe’s Network of patent databases - esp@cenet [online]. Available at: <URL:http://gb.espacenet.com/> [Accessed 2 February 2010].
17. United States Patent Office - USPTO Patent Full-Text and Image Database [online]. Available at: <URL: (http://patft.uspto.gov)> [Accessed 15 February 2010].
18. The UK Patent Office [online]. Available at: <URL: www.patent.gov.uk> [Accessed 27 February 2010].
19. Australia Published Patent Data Searching. Available at: <URL:http://apa.hpa.com.au)> [Accessed 3 March 2010].
20. Canadian Intellectual Property Office [online]. Available at: <URL:http://patents1.ic.gc.ca> [Accessed 7 March 2010].
21. Hellenic Industrial Property Organisation [online]. Available at: <URL:http://www.obi.gr> [Accessed 10 March 2010].

Internet trade literature

22. http://www.rosenbauer.com
23. http://www.camiva.com
24. http://www.tupelofire.com
25. http://www.evotexas.com
26. http://www.tristarbodies.com
27. http://www.newlex-fire.com
28. http://www.hillbillyfire.com
29. http://www.ericksonaircrane.com
30. http://www.sonnet.com/usr/wildfire
31. http://www.helispot.com
32. http://www.conair.ca
33. http://airtractor.com/models
34. http://www.aeronautics.ru
35. http://www.airspray.com
36. http://www.aeronautique.bombardier.com
37. http://www.desastres.org
38. http://www.martinmars.com
39. http://www.firehogs.com
40. http://www.airtanker.com
41. http://www.fs.fed.us
42. http://www.ifex-3000.com

Fire suppression

43. BELL, A., 1987. Water bombing of fires: no magic solution. *Ecos 50:* 19-23.

44. CATCHPOLE, E.A., ALEXANDER. M.E., and GILL, A.M., 1992. Elliptical-fire perimeter and area-intensity distributions. *Canadian Journal of Forest Research 22 (7):* 968-972.

45. CHENEY, N.P., 1985. New approaches to fire danger and fire behaviour. Pages 12.1-12.9 *in* Proceedings of Fire Weather Services Conference, 13-14 May 1985, Adelaide, South Australia. Department of Science, Bureau of Meteorology, Melbourne, Victoria.

46. DAWSON, M.P. 1991л: Fire bans and public perception of fire danger. Pages 33-41 *in* Cheney. N.P.; Gill. A.M. (Ed.) Proceedings. Conference on Bushfire Modelling and Fire Danger Rating Systems, 11-12 July 1988, Canberra, Australian Capital Territory. CSIRO Division of Forestry, Yarralumla, Australian Capital Territory.

47. FORESTRY CANADA FIRE DANGER GROUP, 1992. Development and structure of the Canadian Forest Fire Behavior Prediction System. *Forestry Canada, Science and Sustainable Development Directorate, Ottawa, Ontario. Information Report ST-X-3.* 63 pages.

48. GEORGE, C.W., and JOHNSON, G.M., 1990. Developing air tanker performance guidelines. *USDA Forest Sen'ice. Infermounfain Research Station, Ogden, Utah, General Technical Report INT-26S.* 96 pages.

49. HIRSCH, K.G., 1991. Development of an initial attack preparedness system for Manitoba. Pages 81 -89 *in* Andrews. PL.: Potts, D.F. (Ed.) Proceedings of the l1-th Conference on Fire and Forest Meteorology, 16-19 April, Missoula, Montana. *Society of American Foresters, Bethesda, Maryland, SAF Publication 91-04.*

50. MCALPINE, R.S., and WAKIMOTO, R.H., 1991. The acceleration of fire from point source to equilibrium spread. *Forest Science 37(5):* 1314-1337.

51. PERRY, D.G., 1990. "Wildland Firefighting: Fire Behaviour, Tactics, and Command". Second edition. Fire Publications Inc., Bellflower, California. 412 pages.

52. WIITALA, M.R., 1992. "IASELECT: Initial Attack Resource Selector User's Manual". USDA Forest Service, Pacific Northwest Region, Aviation and Fire Management, Portland, Oregon. 31 pages + appendix.

53. WILSON, R.A., 1987. A theoretical basis for modeling probability distributions of fire behavior. *USDA Forest Service. Intermountain Research Station, Ogden, Utah, Research Paper INT-382.*11 pages.

Fire suppression in the Wildland Urban Interface: A wildland fire technology handbook





Wildland fires are natural calamities that bring enormous environmental and economic damage worldwide. The mediterranean climate countries are subjected to the higher fire risks and all the damage they involve. This book presents a review on related literature involving fire behaviour characteristics and suppression means and techniques for wildland fires. The first part presents characteristics for various fire categories, as well as aerial and ground conventional suppression equipment. The second part gives consideration to unconventional equipment employed in the suppression along with selection criteria for suppression media applicability. Furthermore, reviewed were basic approaches for building the strategy and specific actions to be undertaken in the fire fighting. Finally, models for fire prediction purposes have been also evaluated, as effective fire fighting is associated with predicting the fire behaviour characteristics.

MILTIADIS A. BOBOULOS, Ph.D.